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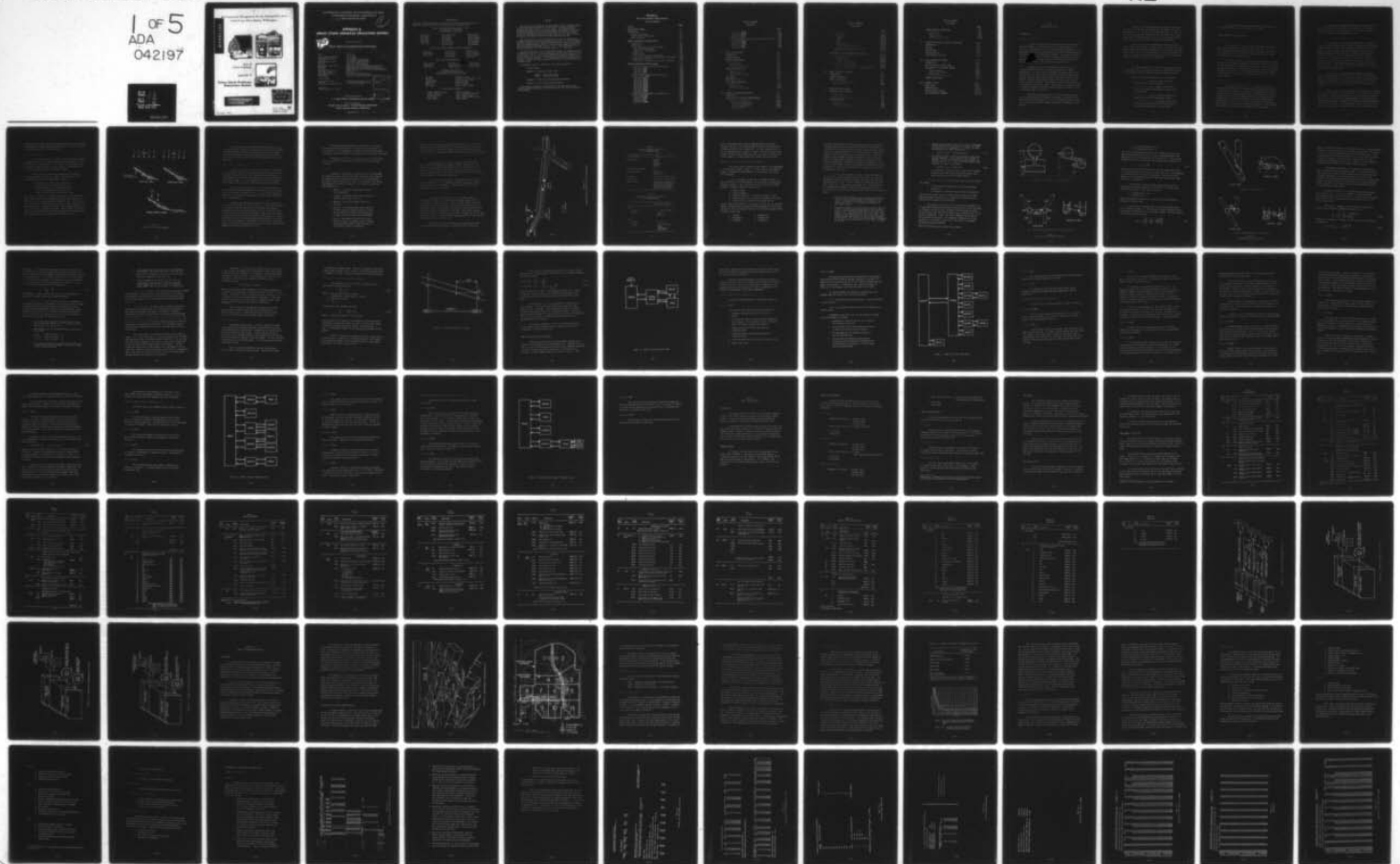
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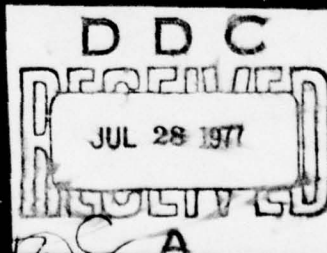
Part II Urban Drainage

Appendix B

Urban Storm Drainage Simulation Models



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December 1974

U. S. Army
Corps of Engineers
Seattle District



6 ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA
CEDAR-GREEN RIVER BASINS, WASHINGTON.
Part II URBAN DRAINAGE STUDY, 1

APPENDIX B
URBAN STORM DRAINAGE SIMULATION MODELS



Technical Direction by

River Basin Coordinating Committee

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PREFACE

This report is an appendix to the Urban Runoff and Basin Drainage Study. It contains program documentation for the urban stormwater computer simulation models and can serve as a user's manual. The computer models described have been used to simulate the quality and quantity of stormwater runoff from drainage sub-basins within the Green and Cedar River Basins (State of Washington Water Resource Inventory Areas 8 & 9) and to develop alternatives for meeting existing and long range drainage needs.

The Urban Runoff and Basin Drainage Study is part of an environmental management program for the Green and Cedar River Basins in King and Snohomish Counties, Washington and has been conducted under the auspices of the River Basin Coordinating Committee (RIBCO). Four principal studies comprise the RIBCO Environmental Management Program: Part I - Water Resources; Part II - Urban Drainage; Part III - Water Quality and Part IV - Solid Waste.

The Urban Runoff and Basin Drainage Report presents a comprehensive plan for meeting the existing and long range urban drainage needs within the Green and Cedar River Basins. The study recommendations address drainage facilities, capital cost, methods of financing and institutional arrangements for effective drainage management. The recommended plans are conceptual and are intended for use by local governments as a guide in the future planning of drainage systems.

The published report is composed of the following documents:

Technical Report

Appendix A - Regional Sub-Basin Plans

A 042 166

Volume 1 - Cedar River Basin

Volume 2 - Green River Basin

Appendix B - Urban Storm Drainage Simulation Models

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Appendix C - Storm Water Monitoring Program

A 042 168

This report is submitted in compliance with the terms of contract DACW67-73-C-0022 between the Seattle District, U.S. Army Corps of Engineers and KCM-WRE/YTO.

APPENDIX B

URBAN STORM DRAINAGE SIMULATION MODELS

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CHAPTER I

DESCRIPTION OF MODELS

INTRODUCTION

HISTORY AND PURPOSE

In October of 1971, under the sponsorship of the Environmental Protection Agency, a consortium of private contractors--Metcalf and Eddy, Inc., the University of Florida and Water Resources Engineers, Inc.--presented a comprehensive mathematical model capable of representing urban stormwater runoff and combined sewer phenomena. The model was comprised of a series of individual sections or blocks which could be used either separately or in combination. The principal elements of the model are the runoff, transport, storage and receiving water blocks.

Subsequent to the initial development the various blocks of the model have been extensively developed and modified in further applications. In a major study of stormwater drainage for the City of San Francisco, the runoff block was updated to include revised concepts of gutter flow and the transport model was rewritten to develop a model capable of handling looped networks typical of sewers, plus irregular piping systems and surcharge. These models have been developed expressly to simulate urban stormwater runoff. Their purpose is to provide a means of assessing problems in an urban drainage system and to provide a means of examining potential solutions.

The models developed for the City of San Francisco are those which have been updated and modified, particularly with respect to the number of quality constituents, for use in the Seattle Metropolitan area. It is a description of these computer models which is presented in this document.

PREVIOUS MODEL APPLICATIONS

In the original development work the stormwater models were applied to test watersheds in San Francisco, Philadelphia, Cincinnati and Washington, D.C. The San Francisco and Washington, D.C. areas were later more comprehensively analyzed for the local authorities. Major studies have also been undertaken in the cities of Chicago, Illinois; Boston, Massachusetts; and Hamburg and Landau in West Germany.

Individual blocks of the comprehensive model have proved useful in more limited studies in other areas. For example, the runoff block has been used to design overflow facilities in the City of Corte Madera, California, and the transport block in various flow studies for the City of Albany, the East Bay Municipal Utility District and Marin County Flood Control District, all in California.

BLOCK STRUCTURE

The models described herein consist of four primary sections or blocks which are used to simulate the quality and quantity of flow from a watershed, through a sewer, and then to display the results.

Specifically, the blocks described in this report are:

1. *Display Block* - A graphical output routine for producing plots on the line printer.
2. *Runoff Block* - A set of computer routines which simulates the quality and quantity of surface flow from watersheds.
3. *Transport Block* - A set of computer routines which dynamically routes flow through sewer systems.
4. *Transport Quality Block* - A computer routine which uses the flow simulation of the Transport Block to route quality constituents in sewer systems.

Please note that the receiving water model developed in the above-mentioned EPA work is not included in this report.

GENERAL DESCRIPTION OF MODEL BLOCKS

DISPLAY BLOCK

The Display Block is a set of four subroutines which produce plots of specified system variables on the line printer. The items which may be displayed are the input rainfall hyetographs, the output flow hydrographs from the Runoff and Transport Blocks, and the output pollutographs for quality constituents.

The routines included in the Display Block have been programmed such that they are general in operation and employ a Calcomp-like calling sequence in their formal arguments. Note that the routines of the Display Block produce continuous lines between data points, a feature not usually included in printer plots. A more complete description of the elements in the Display Block can be found in Reference 1 and in later sections of this chapter.

RUNOFF BLOCK

The Runoff Block consists of a set of computer routines and appropriate data which will simulate the rainfall-runoff characteristics of an urban area. Certain of its internally programmed quality characteristics have been found from observations in the Seattle area and thus the model must be considered somewhat specific at the present time. In the model flow is traced from the onset of rainfall to the watershed, through overland flow, and then to flow in the gutters and minor sewers. Water quality mass emissions are generated as they occur on the watershed surface and in the catch basins which comprise the total system.

In the following paragraphs only general descriptions are given to the technical methods employed in the Runoff Block. The reader is directed to Reference I and to Chapter V for a detailed explanation of the model's formulation and its numerical solution.

Model Idealization of the Watershed

It is important to recognize that any model is an idealization of the real system in some sense. A model is intended to portray certain important characteristics of the prototype system realistically and the degree to which it does so is the primary measure of its validity. Whenever possible, it seems desirable to represent the real world by a model which conforms to our best knowledge of the actual processes taking place. In a hydraulics problem, for example, we will work with the familiar entities of flow, inertia, continuity, etc., albeit in an idealized fashion. Sometimes the real system is too complex for this kind of treatment and we resort to statistical measures or curve fitting descriptions of the phenomenon.

The processes simulated by the Runoff Model are extremely complex and interrelated. The model is based both on the fundamental physics of hydromechanics and on the best of carefully developed sanitary engineering technology. Tests of the model show that it fulfills the criterion set forth above--realistic portrayal of important prototype behavior.

Hydraulic flow in the Runoff Model is represented by the kinematic wave solution for flow across a plane surface. This rather simple approach is applied to a geometric representation of an urban area which includes the major hydrologic sub-units of surface drainage. In the model each of the watershed sub-units is treated as if it were completely independent of all others in the system. This idealization is basic to the structure of the Runoff Model; when it is found that this is not a good approximation

corrections must be made by changing watershed boundaries or creating new unit watersheds. Linkage between major watersheds is usually accomplished in the Transport Model, not the Runoff Model.

Flow From the Watershed

It is convenient now to consider in detail the methods employed in modeling flow from one of these independent watershed units. Clearly, the problem is extremely complex. It involved flow from building roofs, parking lots, lawns, playfields, streets, gutters, a sewer network and all other features which make up the urban landscape.

We shall begin our analysis by considering the idealized watershed indicated in Figure I-1. Figure I-1 shows the three types of drainage units found in each watershed. These are:

1. Pervious areas - parks, lawns, gardens, etc.
2. Impervious areas - roofs, paved areas, etc.
3. Minor sewer elements - all sewers, gutters, or similar conveyance paths which collect the runoff from the pervious and impervious areas

Each of these is treated as an overland flow problem. The magnitude of flow is determined from the kinematic wave solution mentioned earlier. Rain falls directly on the pervious and impervious areas. On the former, some is lost by infiltration to the ground water. After deducting losses flow moves from the watersheds to the minor sewer elements where the total flow is accumulated. Outflow from the minor sewer elements is routed to other minor sewer elements in the surface system, and its magnitude stored by the computer routine for later use in the Transport Block.

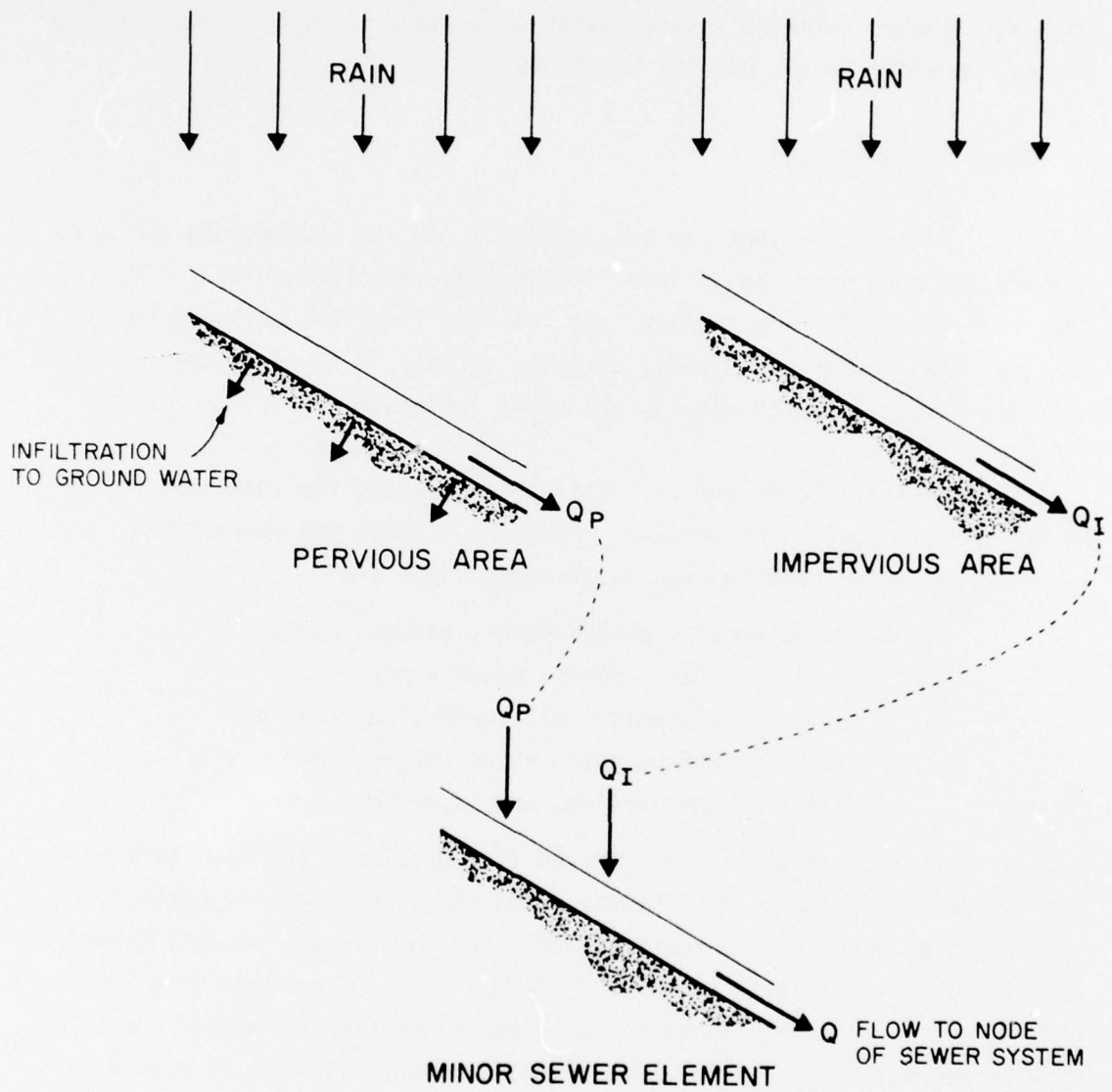


FIGURE I-1
SEQUENCE OF FLOW FROM WATERSHED

The model assumes that the pervious and the impervious areas are separate within the watershed, each of which drains into the adjacent street-gutter-sewer system which constitutes the minor sewer element. The minor sewer element collects the watershed flows and accounts for the lag time introduced by the distance from the watershed to the major sewer node.

Quality From the Watershed

The quality of the surface runoff is important in the analysis of urban systems, and more than 20 water quality constituents have been included in the Runoff Model. The contribution from each subarea for each constituent is determined by combination of land use and equivalent street-gutter length. It is the responsibility of the user to specify each of these values for all unit watersheds in the total watershed.

The constitutive relationships for all quality parameters in the Runoff Model have been determined from observations of actual sewer quality in the Seattle Metropolitan area. For this reason the quality model must be considered relatively specific to the Seattle Metropolitan area for the present time.

The Runoff Quality Model considers two sources of pollution; the watersheds themselves and street catch basins. The buildup and amount of pollutant in each are made functions of both the street sweeping frequency and the number of days without rain prior to any given storm. At the outset of the simulation an estimate is made of the total amount of pollutant contained in and on each of the system elements. As rainfall begins pollutants move from the watersheds and catch basins to the minor sewer areas of the system. A mass balance is calculated for each system element at each time step and estimates are made for quality concentrations expected over the entire duration of a storm.

The rate of pollutant removal is proportional to the rate of rainfall and the amount of pollutant remaining on the watershed or in the catch basin. All constituents are routed conservatively, and output is produced, printed or plotted at any combination of preselected system nodes.

The water quality model is an integral part of the Runoff Block but it is possible to run the quantity simulation without the quality simulation.

Input Data

The geometric and hydraulic properties of the unit watersheds are required in a form consistent with the idealization of the area and yet compatible with an ordinary understanding of the topography and hydrology of urban drainage areas. Details of the computer card format requirements are contained in Chapter II. The quantities needed for each watershed are:

1. Rainfall: the rainfall hyetographs pertinent to the watershed.
2. Linkage: a watershed identification number and the sewer node to which it drains.
3. Geometry: the size and length of each unit watershed.
4. Hydraulic: the average ground slope, hydraulic resistance factors, percent impervious, surface storage (parking lot ponding, surface adherence to trees, etc.), and infiltration coefficients.
5. Quality: the number of dry days prior to the onset of rainfall, the street cleaning frequency, and the equivalent gutter length and number of catch basins for each unit watershed.

Certain of the required data must be supplied by the user. In other cases the program will select default values if the user elects not to specify them. The reader is referred to Chapter II and the examples of Chapters III and IV for more complete descriptions of data needs and problem structure.

TRANSPORT BLOCK

The Transport Block is a set of computer routines and data which simulate the movement of stormwater through a sewer system. The model uses as input specific hydrographs such as those produced by the Runoff Block. The Transport Block can be used to simulate quantity only with the Transport Model or both quantity and quality with serial operation of the Transport and Transport Quality Blocks.

A fairly detailed description of the elements of the Transport Block is presented as it is a completely different formulation of sewer flow from that given in Reference 1. Even more detail on the solution technique can be found in Chapter V.

Model Idealization of a Storm Sewer

The conceptual representation of a storm sewer system is illustrated in Figure I-2. It employs the link-node concept, with the basic elements listed in Table I-1. In the transport model the property of volume is ascribed to the nodes. The solution technique applies the continuity equation, with storage, to each node in the system and computes the hydraulic head at the manholes or junctions. These heads, together with the friction and momentum forces, are used to compute the flow through the pipes or links. A summary of the properties ascribed to links and nodes in the model are listed in Table I-2.

By applying the continuity equation with storage to the nodes and then using the resulting heads to compute the flow in connecting

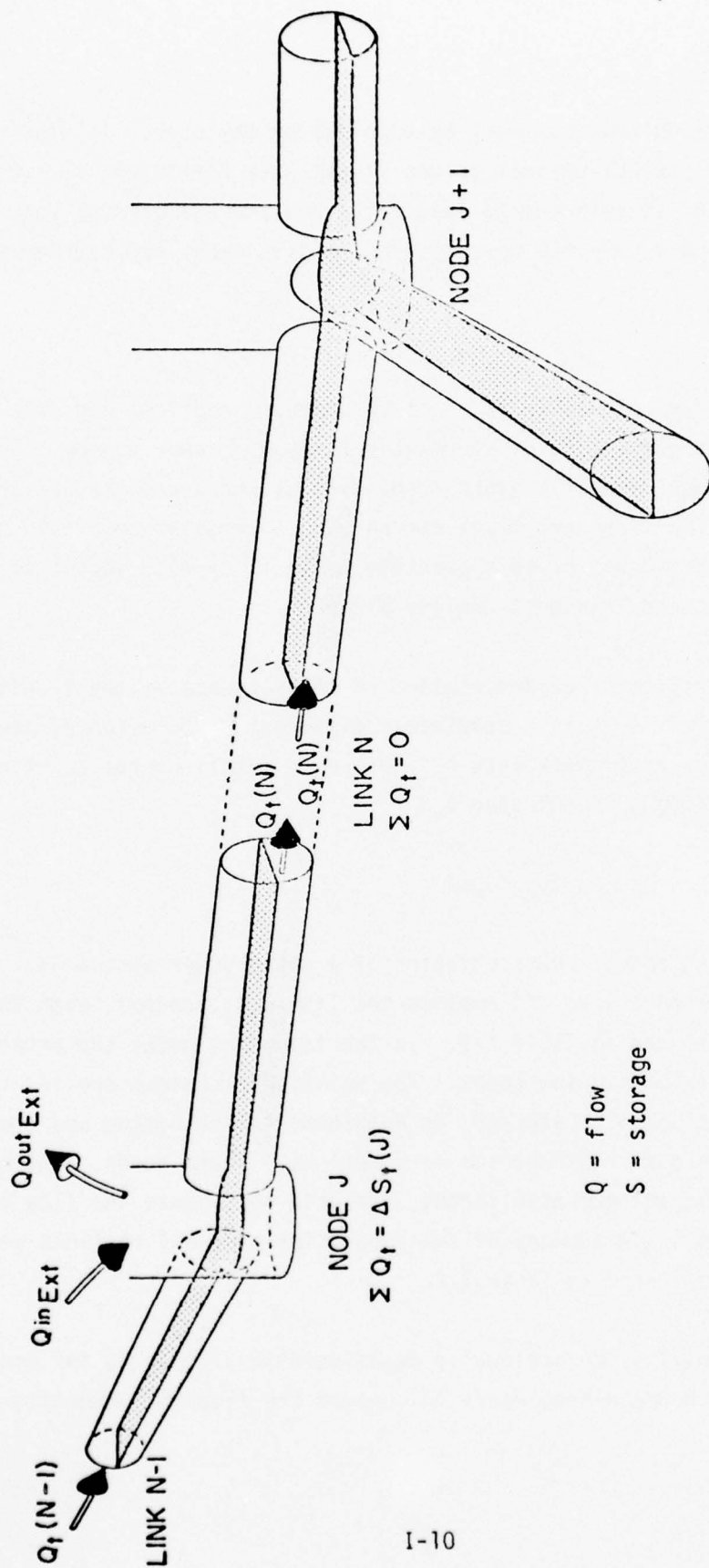


FIGURE I-2
CONCEPTUAL REPRESENTATION OF THE TRANSPORT MODEL

TABLE I-1
CLASSES OF ELEMENTS INCLUDED IN
THE TRANSPORT MODEL

Element Class	Types
Conduits or Links	Rectangular Circular Horseshoe Baskethandle Eggshape Trapezoidal
Junctions or Nodes (Manholes)	-----
Diversion Structures	Orifices Transverse Weirs Sideflow Weirs
Pump Stations	On-line or off-line lift station
Storage Basins	On-line (enlarged pipes or tunnels)
Outfall Structures	Transverse weir with tide gate Transverse weir without tide gate Sideflow weir with tide gate Sideflow weir without tide gate Free outfall with tide gate Free outfall without tide gate

TABLE I-2
PROPERTIES OF THE LINKS AND NODES IN
THE TRANSPORT MODEL

Properties and Constraints	
NODES	
Constraint	ΔQ = change in storage
Properties	Volume Surface area Head
LINKS	
Constraint	$Q_{in} = Q_{out}$
Properties	Cross sectional area Length Roughness Hydraulic Radius Surface Width

links, the backwater effect can be propagated through the system. Moreover, the use of this technique makes the order of computing heads at nodes and flows of links unimportant. All water transfers into or out of the system occur at nodes, i.e. weir or orifice diversions to dry weather interceptor lines, pumping stations, and outfalls, inflows from surface runoff, or inflows diverted from another part of the system.

Definition of System Elements and Data Requirements

The various types of sewerage system elements to be represented in the model were listed in Table I-1. In this section, the geometric - hydraulic properties of these elements as they are used in the model will be defined.

Conduits - Conduits are the primary conveyance elements in the system and it is to these elements that the dynamic non-steady flow equation is applied. Thus, for each pipe in the system the following geometric - hydraulic parameters are required:

1. Conduit length,
2. Conduit roughness,
3. Cross sectional area as a function of depth of flow,
4. Hydraulic radius as a function of the depth of flow, and
5. Surface width as a function of the depth of flow.

Conduit length and roughness must be supplied as input data for the model. However, the functional relationships between parameters 3, 4 and 5 and the depth of flow are retained internally in the computer program for the following conduit types:

- | | |
|-----------------|------------------|
| 1. Circular, | 4. Baskethandle, |
| 2. Rectangular, | 5. Eggshape, and |
| 3. Horseshoe, | 6. Trapezoidal. |

For each of the parameters indicated, an array of values is stored for each pipe type which gives the ratio of the value of the parameter at a given depth to its maximum value for the pipe. While the arrays contain values for rectangular conduits, it is more efficient to compute the parameters for both rectangular and trapezoidal sections. The maximum values of these parameters are the cross-sectional area of the pipe, width at the springline, and height of the pipe. The idea of storing arrays of fractions was originally conceived in the development of the Florida Transport Model, and it is an extremely efficient way to maintain the geometric - hydraulic characteristics of a large number of pipes of different types and sizes.

Junctions - The junctions, or nodes, in the system represent the on-line, or in-pipe, storage capacity of the system. In addition the hydraulic heads at the nodes are used to drive the flow through the connecting pipes or links. Table I-2 showed the properties associated with a node to be: volume, head, and surface area. Referring again to the conceptual representation of the node illustrated in Figure I-2, it is seen that the properties of the node can be defined in the following manner.

1. For each conduit connected to the node under consideration (call it node j) the water depth at the midpoint of the conduit is computed as the average of the depths at the ends of the conduit i.e. the average of the depths at the connecting nodes.
2. The surface widths at the midpoint and at the end connecting to node j is then found using the depths of flow at these points and the appropriate lookup table as described above under *Conduits*. The free surface area of the pipe is then computed as the product of the average of the widths at the midpoint and the end of the conduit times the half-length of the conduit. The surface area $AS(j)$ of node j is computed as the sum of the surface areas of the half-pipes connected to the node.

3. Assuming that any excess inflow into a node is distributed uniformly over the water surfaces of the node, the change in head at node j is computed as $\Delta H = (\Sigma Q)_j / AS_j$ so that the new head at the node is expressed as

$$H_j(t+\Delta t) = H_j(t) + [\Sigma Q(t+\Delta t)]_j / AS_j(t) \quad (I-1)$$

4. The volume of water in storage at the node is never used for any computation. It is saved only as a parameter of interest. At any time the change in volume at node j is computed simply as $\Delta V_j = (\Sigma Q)_j$ so that the volume of water contained at a node is expressed as

$$V_j(t+\Delta t) = V_j(t) + [\Sigma Q(t+\Delta t)]_j \quad (I-2)$$

Of course when all pipes are full V_j takes on the maximum storage value of the node and $[\Sigma Q(t+\Delta t)]_j$ becomes flood water which flows out of the flooded junction.

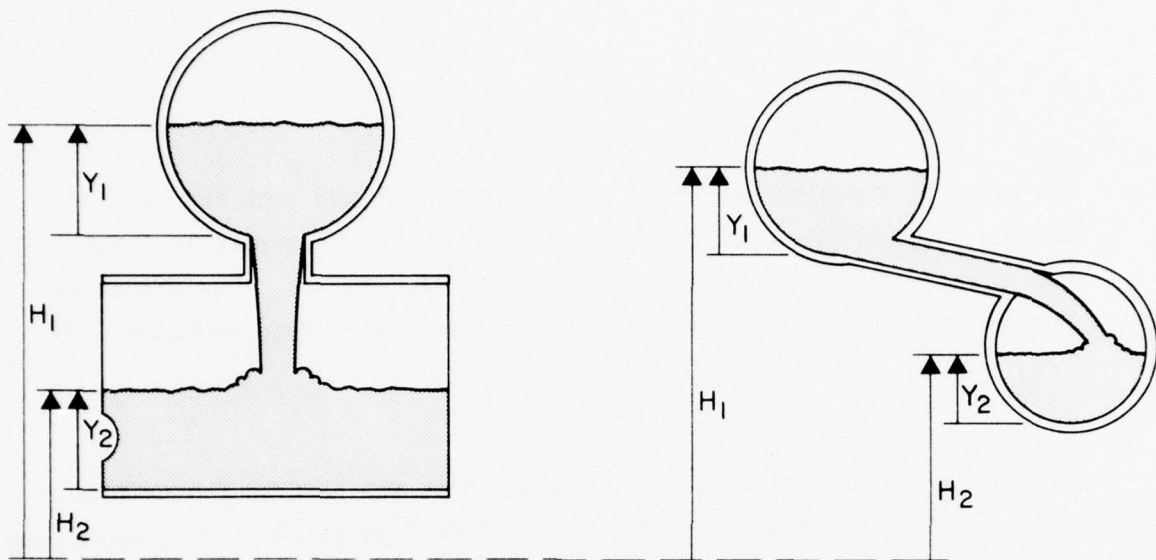
Diversion Structures - Diversion structures are used for one of two purposes:

1. To divert sanitary sewerage out of the storm drainage system, and
2. To relieve the stormwater load on sanitary interceptors.

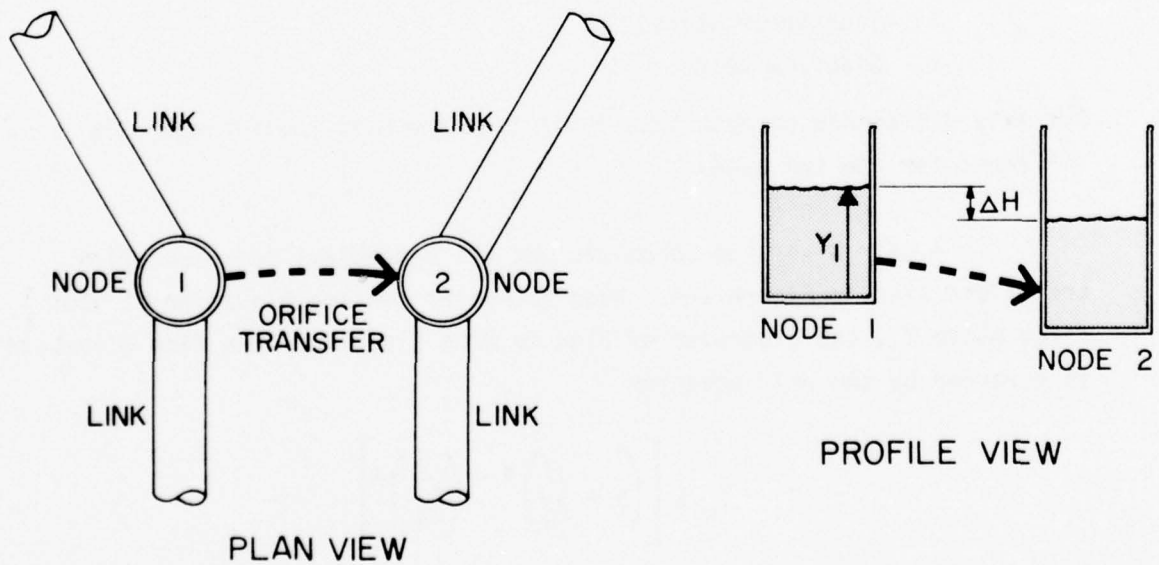
These diversions always occur at a node with the transfer being made between two nodes.* Descriptions of the hydraulic characteristics of these diversion structures are given below.

The purpose of the orifice is to divert sanitary sewage out of the stormwater system during dry weather periods and to restrict the entry of stormwater into the sanitary interceptors during periods of runoff. The orifice may divert the flow to another pipe, a pumping station, or an off-line storage tank. Figure I-3A shows a schematic of two types of orifice diversion structures. The conceptual representation as used the model is illustrated in Figure I-3B. The orifice is completely characterized by two parameters:

*There is no pipe connection between the two nodes.



A. Schematic of Two Types of Orifice Diversions



B. Conceptual representation of an Orifice Diversion

FIGURE I-3
REPRESENTATION OF ORIFICE DIVERSIONS

1. Its cross-sectional area A, and
2. A discharge coefficient, C_o .

The value of the discharge coefficient, which depends upon the type of opening and the length of the orifice tube, is pre-specified as input data along with the cross-sectional area of the orifice. The discharge through the orifice is computed with the standard orifice equation, i.e.

$$Q_o = C_o A \sqrt{2gh} \quad (I-3)$$

where g is the gravitational constant and h is the head on the orifice i.e. the minimum value of $(H_1 - H_2)$ and Y_1 (See Figure I-3). This expression is used even when the orifice is not submerged. The resulting error, however, is not considered significant since these flows are small when the orifice is unsubmerged.

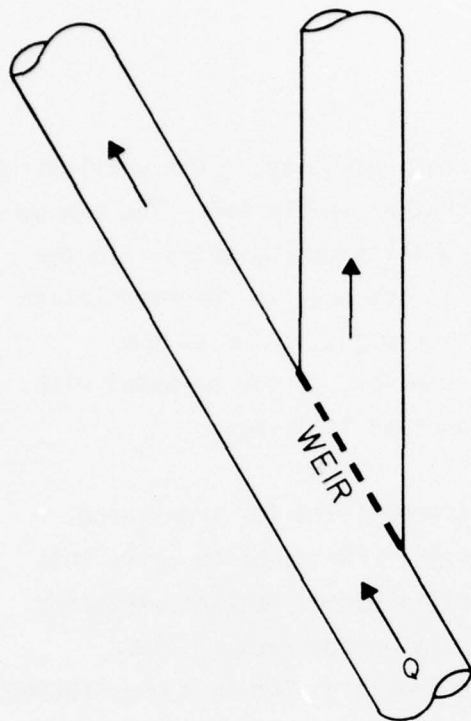
Weir diversion in the storm sewer system provide relief to the sanitary sewers during periods of storm runoff. Two types of weir diversions are treated in the simulation model:

1. Transverse weirs, and
2. Sideflow weirs.

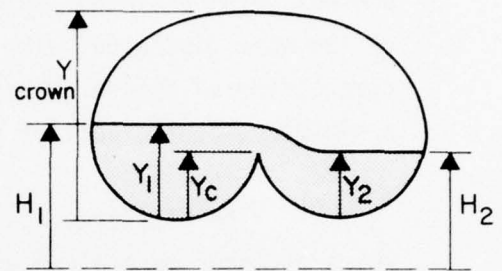
The only difference computationally is that the weir coefficients are different for the two cases.

A weir diversion schematic and its conceptual representation are illustrated in Figure I-4. When the water surface elevation at Node 1 rises above Y_c , the diversion of flow to Node 2 begins. The flow diversion is governed by the weir equation

$$Q_w = C_w L \left[\left(h + \frac{v^2}{2g} \right)^a - \left(\frac{v^2}{2g} \right)^a \right] \quad (I-4)$$

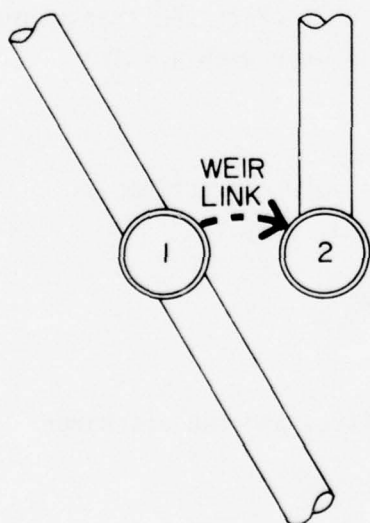


PLAN VIEW

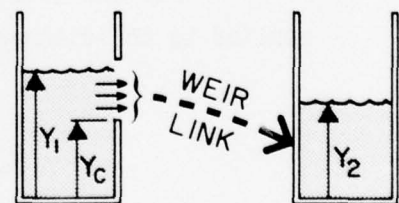


PROFILE VIEW

A. Schematic of a Weir Diversion



PLAN VIEW



PROFILE VIEW

B. Conceptual Representation of a Weir Diversion

FIGURE I-4
REPRESENTATION OF WEIR DIVERSIONS

where h is the head on the weir, V the approach velocity, g the gravitational constant, L the weir length and C_w the discharge coefficient. The exponent a is set at $3/2$ for transverse weirs and $5/3$ for sideflow weirs. In the present version of the computer program, V is not used in the computation of the weir discharge. The value is set to zero just prior to the computation of discharge by Equation I-4. However, it can be added with a minimum amount of effort if the need to include it arises.

The discharge coefficient C_w is prespecified for transverse weirs as input data along with the weir length. For sideflow weirs this input coefficient should be modified internally during program execution to reflect the effect of the approach velocity on the rate of flow diversion. The computer program contains a provision for this computation; however, the present expression simply equates the discharge coefficient to the input value. The correct expression can be formulated, however, and incorporated into the program.

The head over the weir, h is computed as the minimum value of $(Y_1 - Y)$ and $|H_1 - H_2|$. If $H_1 - H_2$ is negative, a backflow condition exists and the flow is from Node 2 to Node 1. In this case, the transverse and sideflow weirs are both treated as a transverse weir with $a = 3/2$ and $C_w = \text{input value}$.

If the weir is submerged, the Villamonte weir correction is applied to the discharge Q_w computed by Equation I-4, i.e.

$$Q'_w = Q_w \left[1 - \left(\frac{Y_2 - Y_c}{H_1 - H_2} \right)^a \right]^{0.385} \quad (\text{I-5})$$

If the weir is surcharged, it behaves like an orifice, and the discharge is expressed as

$$Q_w = C'_w [L (Y_{\max} - Y_c)] \sqrt{2gh + V^2} \quad (\text{I-6})$$

where $(Y_{\max} - Y_c)$ is the distance between the weir crest and the top of the pipe. The only difference between this expression and equation 4 is that the velocity head of the approach flow has been included for the case of the submerged weir. The discharge coefficient C'_w for the surcharged case is an input value. However, if Equations I-4 and I-6 are equated at $Y = Y_{\max}$, and the effect of the velocity heads is neglected (i.e. set $v^2 = 0$ in the two expressions) it can be shown that

$$C'_w = \frac{C_w}{\sqrt{2g}} \approx \frac{C_w}{8} \quad (I-7)$$

The exponent a is taken as $3/2$ in this case. It is recommended that Equation I-7 be used to define C'_w in model applications.

Pump Stations - A pump station is conceptually represented as an off-line storage node (the wet-well) from which the contents are pumped to another node in the system according to a programmed rule curve. Inflows to the storage node may be diverted from the main sewer system through an orifice, a weir, or a pipe with a free discharge condition at the storage node. The pumping rule curve is based on the volume of water in the storage node. It operates as follows:

1. Up to three wet-well volumes are prespecified as input data for each pump station: $V_1 < V_2 < V_3$, where V_3 is the maximum capacity of the wet well.
2. Three pumping rates as also prespecified as input data for each station:
 - R_1 for volume in wet well $< V_1$
 - R_2 for $V_1 < \text{volume in wet well} < V_2$
 - R_3 for $V_2 < \text{volume in wet well} < V_3$
3. A mass balance of outflows as specified by the rule curve in item 2 and inflows is performed in the wet well during the model simulation period.

4. If the wet well goes dry the pump rate is reduced below rate R_1 until it just equals the inflow rate. When the inflow rate again equals or exceeds R_1 , the pumping rate goes back to operating on the rule curve.
5. If V_3 is exceeded in the wet well, the inflow to the storage node is reduced until it does not exceed the maximum pumped flow. When the inflow falls below the maximum pumped flow, the inflow "gates" are opened again.

Storage Basins - Table I-1 shows that the transport model includes on-line storage. On-line storage is that storage that is available in the system by virtue of the fact that the pipe and conduits which make up this system store water. On-line storage was described above under *Junctions*.

Outfall Structures - The basic outfall structures that can be simulated by the transport model are weir outfalls and free outfalls, both types with or without tide gates. The hydraulic - geometric characteristics of the free outfall weir have been described above under *Diversion Structures*. It should be noted that for the free outfall weir (no tide gate) it is tacitly assumed that the condition of backflow across the weir will never occur! If a backflow situation does occur, the flow over the weir is automatically set to zero. This procedure in effect prevents receiving waters from flowing into the sewer system over free outfall weirs.

The "free outfall" is a pipe that discharges to the receiving waters. It is truly a free outfall if the receiving waters are low enough that they do not affect the hydraulic head at the outfall. For this case the water surface elevation at the outfall is taken as the minimum value of the critical and normal depths at the given discharge. Discharge through the outfall pipe is then computed in the same manner as for any other link. When the receiving water backs up into the pipe, the hydraulic head at the outfall is taken as the larger of the free discharge heads and the receiving water elevation of the outfall.

When there is a tide gate on an outfall weir or a free outfall, a check is made to see whether or not the hydraulic head inside the gate exceeds that outside of the gate. If it does not, the discharge through the outfall is equated to zero. If the driving head is positive, then the ARMC0 tide gate correction is applied and the driving head is reduced by an amount

$$\Delta h = \frac{4}{g} V^2 \exp (-1.15 V/\sqrt{h}) \quad (I-8)$$

where h is the hydraulic head on the weir or the free discharge head in the absence of the tide gate, V is the velocity over the weir or in the conduit. In the case of the weir, the driving head in Equation I-4 or I-6 is reduced by an amount Δh and the discharge recomputed. For the free outfall, the hydraulic head at the outfall is raised an amount Δh thus decreasing the driving head in the conduit by that amount.

The time history of the hydraulic information is stored on magnetic tape and interfaced with the Quality Transport Block. It would have been logical to combine the quality and transport models, but it is not possible because of computer storage requirements.

TRANSPORT QUALITY BLOCK

The Transport Quality Block is a simple, advective flow model. It uses the quality constituents generated by the Runoff Block and the flows computed by the Transport Block in combination to trace the quality constituent through the sewer system. It would have been logical to combine quality and quantity portions of the Transport Block but this was not possible because of computer storage requirements. It may be considered a post-processor to the transport model. It is the shortest and simplest of the model routines.

Output from both the Runoff Block and the Transport Block serves as input to the Quality Transport Block. Data from both models

is transferred via magnetic tape. There are no subroutines used by this program except standard library routines. All operations are performed in sequence, i.e. there is no major alternate path through the program.

Mathematical Idealization and Solution Technique

The mathematical basis of the Quality Transport model is the equation of mass conservation,

$$\frac{\partial M}{\partial t} = CQ \quad (I-9)$$

where M = mass of constituent at a section

C = concentration of constituent at a section

Q = flow past the section

t = time.

Converting mass into concentration yields

$$\frac{\partial C}{\partial t} = - \frac{C}{V} \frac{\partial V}{\partial t} + U \frac{\partial C}{\partial X} \quad (I-10)$$

where U = velocity of flow and V = nodal volume.

The right hand side of Equation I-10 represents the two effects which contribute to concentration changes at a point. The first term, $\frac{C}{V} \frac{\partial V}{\partial t}$, is the dilution taking place at the section. The second term, $U \frac{\partial C}{\partial X}$, is the advective movement of the concentration gradient past the section.

Figure I-5 illustrates the advective term for a single conduit, n, during a small, finite time Δt . The entire gradient slides forward due to advective transport so that the concentration, \hat{C} , which began a distance $U_n \Delta t$ from node 2, moves to node 2.

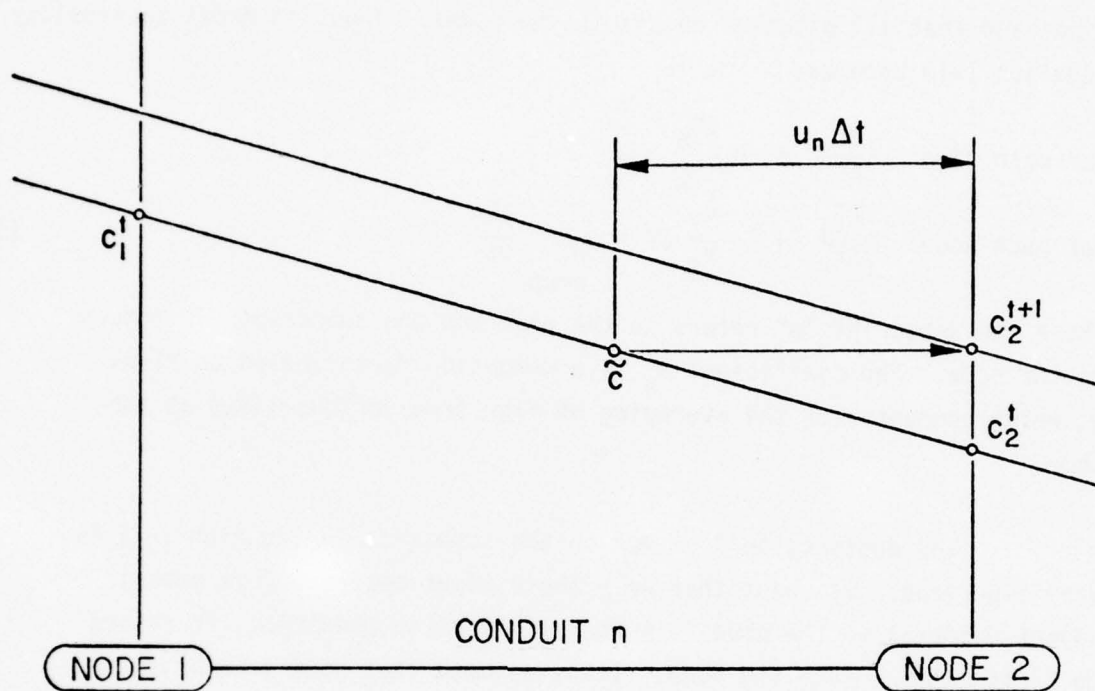


FIGURE I-5 ADVECTIVE MOVEMENT IN A CONDUIT

In the model we assume that only advective flow occurs in the pipes and that all dilution occurs in the nodes. Thus, in model terminology Equation I-10 becomes:

$$\text{For each pipe: } \frac{\Delta C_n}{\Delta t} = U_n \frac{\Delta C_n}{L_n} \quad (I-11)$$

$$\text{For each node: } \frac{\Delta C_j}{\Delta t} = - \frac{C_j}{V_j} \Delta V + \alpha_n \sum_{n=up} \frac{\Delta C_n}{\Delta t} \quad (I-12)$$

where the subscript "n" refers to the pipe and the subscript "j" refers to the node. The coefficient α_n is a weighting factor based on flow, Q, which accounts for the averaging of flow from various lines at the node.

The designation "n = up" on the summation in Equation I-12 is very important. It means that only those pipes upstream from node j advect material to the node. In the reverse flow condition, it refers to pipes flowing into the node. It is assumed that node j is blind to events downstream and does not receive water quality inputs from downstream. This is a valid assumption for moderate to rapid conduit flow, well substantiated in the literature.

In the model, Equations I-11 and I-12 are solved alternately in the conduits and at the nodes, so that a complete time history of concentration is obtained at each node.

COMPUTER PROGRAM DESCRIPTION--FORMAT

Detailed descriptions of each of the computer programs which comprise the four program blocks are presented below. Presented for each block is a short narrative description of each of its component subroutines. Functional flowcharts of program logic plus a list of definition of variables in FORTRAN COMMON storage are included in Chapter V. These

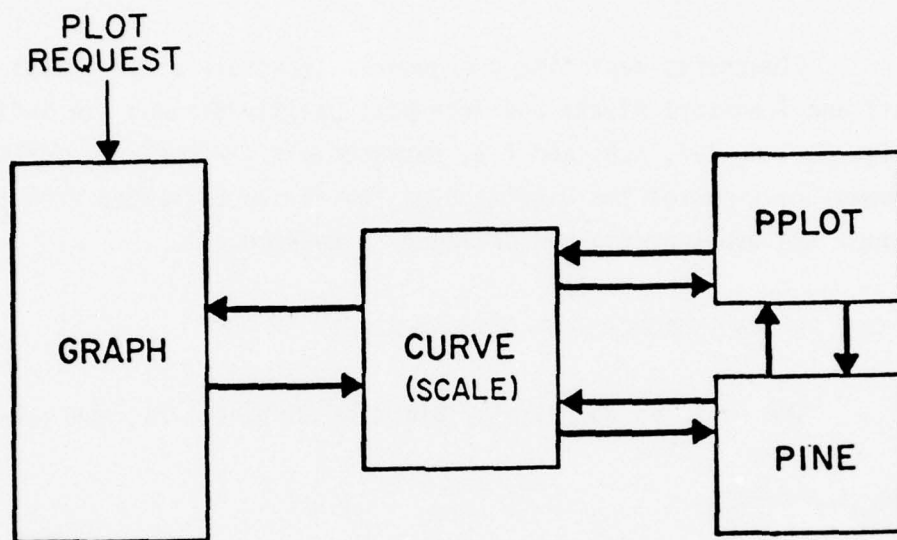


FIGURE I-6 GENERAL STRUCTURE DISPLAY BLOCK

descriptions, together with the program listings, should enable anyone familiar with computer programming to identify problem areas or places for desired program modifications.

Flowcharts depicting the general structure of the Display, Runoff and Transport Blocks and Transport Quality Blocks, are indicated in Figures I-6, I-7, I-8, and I-9, respectively. Flowcharts for the component routines of the Display Block which are unchanged from the original EPA development, can be found in Reference 1.

COMPUTER PROGRAM DESCRIPTION--DISPLAY BLOCK

The logic of the Display Block is indicated in Figure I-6.

Subroutine CURVE

The subroutine CURVE performs the following operations:

1. Determines maximum and minimum of arrays to be plotted.
2. Calculates the range of values and selects appropriate scale intervals. In the Transport Block, a subroutine SCALE is included to perform this function.
3. Computes vertical axis labels based upon the calculated scales.
4. Computes horizontal axis labels based upon the calculated scales.
5. Joins individual parts of the curve by subroutine PINE.
6. Outputs final plot.

Subroutine GRAPH

The graphing subroutines enable hydrographs and pollutographs to be plotted on the printer for selected locations on the data file. GRAPH is the driving subroutine, and it calls CURVE to produce the actual page of plotted output. In the Runoff Block subroutine HCURVE calls CURVE, and in the Transport Block subroutine OUTPUT calls CURVE.

The subroutine GRAPH (IC) operates on two modes which are dependent upon the value of IC in the calling sequence.

If IC = 0 (when called by the Runoff Block), control information is read from cards.

If IC = 1, both control information and title information are read from cards.

Subsequently, both options join and the subroutine proceeds as one flow sequence as follows:

1. Information is read from the data file indicating the structure of that file.
2. An array ITAB is set up indicating which locations of the data file record are to be plotted.
3. All hydrograph and pollutograph information is read from the data file.
4. For each type of hydrograph and pollutograph, individual curves are selected, transferred into plotting arrays, and outputted in a final plotted form by subroutine CURVE.

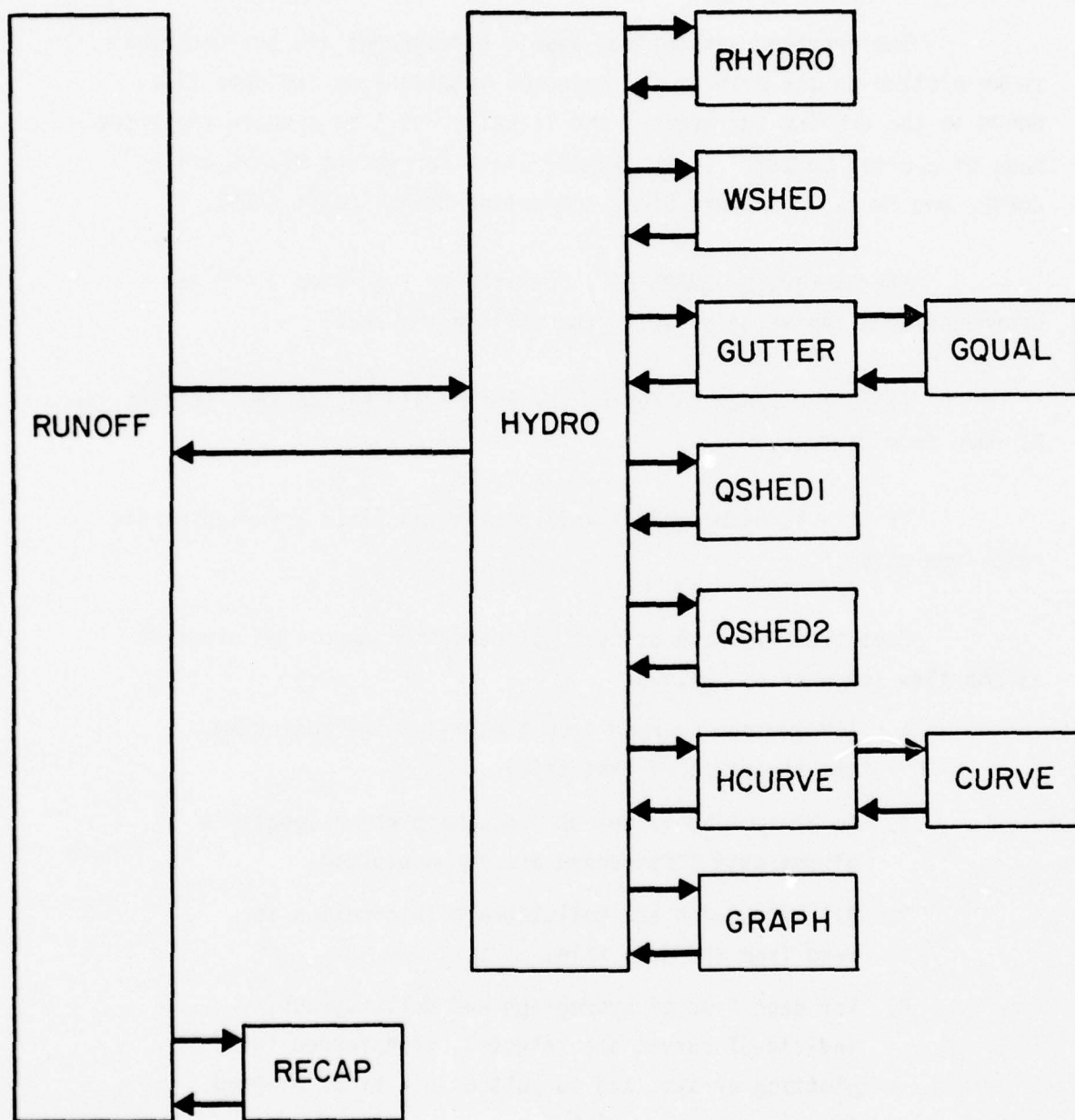


FIGURE I-7 GENERAL STRUCTURE RUNOFF BLOCK

Subroutine PINE

This subroutine joins two coordinate locations with appropriate characters in the output image array A of PLOT.

Subroutine PLOT

This subroutine initializes the plotting array, stores individual locations, and outputs the final image array A for the printer plot.

COMPUTER PROGRAM DESCRIPTION--RUNOFF BLOCK

The overall logic for the Runoff Block is shown in Figure I-7.

Main Program RUNOFF

This is the main routine of the Runoff Block. This program prints a heading and then acts as the driver routine for the block. Figure V-6 is the appropriate flowchart.

Subroutine GQUAL

This subroutine, Figure V-7, computes a mass balance for each gutter at each time step. The routine accounts for the mass rate of flow into a gutter from upstream sources as well as that from tributary watersheds and local catch basins. The output from this routine is an estimate of the water quality expected in the system gutters at each time step.

Subroutine GUTTER

The function of subroutine GUTTER is very similar to that of WSHED and is shown in Figure V-8. It calculates a complete set of water depth and flow for gutters and pipes.

The computation also proceeds one gutter at a time. For a gutter, the inflow from tributary subcatchments and gutters is first computed. Newton's iterative procedure is again used to determine the depth and outflow of gutters so that the mass (volume) of water is conserved. The flow is computed by Manning's equation. The hydraulic radius of trapezoidal gutters and circular pipes is calculated separately in different paths of the program.

A pipe may surcharge when it is full and the inflow is larger than the outflow capacity. In this case, the surcharged amount will be computed and stored at the head end of the pipe. A message will be printed to indicate the time, location, and total amount of the surcharge. The pipe will remain full until the stored water is completely drained.

Subroutine HCURVE

HCURVE, Figure V-9, performs some functions of subroutine GRAPH, and is designed to call subroutine CURVE to plot the hyetographs and the inlet hydrograph.

Subroutine HYDRO

This subroutine, shown in Figure V-10, computes the hydrograph coordinates with the assistance of three core subroutines, i.e. RHYDRO, WSHED, and GUTTER, as shown in Figure I-7. It initializes all the variables to zero before calling RHYDRO to read in the rainfall hyetograph and information concerning the inlet drainage basin. According to the

upstream and downstream relationship, the subroutine sequences the computational order for gutters/pipes.

A DO loop is formed to compute the hydrograph coordinate for each incremental time-step. In each step, subroutine WSHED is first called to calculate the rate of water flowing out of the idealized subcatchments. GUTTER is then called to route the flow, according to the input from tributary subcatchments and gutters. Water flowing into the inlet point, be it from gutters or direct drainage from subcatchments, is added up for a hydrograph coordinate.

During the process of computation, an accounting is made for the deposition of rainfall water in the form of runoff, detention, and infiltration loss. A mass continuity can therefore be checked and printed for reference.

Finally, the rainfall hyetograph and the inlet hydrograph are plotted as an output. The control is then returned to subroutine RUNOFF.

Subroutine QSHED1

Subroutine QSHED1, shown in Figure V-11, is used to estimate the initial mass of pollutant on the unit watersheds and in the system catch basins at the beginning of a storm. This is done by applying empirically determined pollutant buildup factors for the number of dry days prior to a storm and then reducing the total by the amount taken up by street cleaning.

Subroutine QSHED2

QSHED2, Figure V-12, is used to estimate the mass rate of pollutant runoff from watersheds and catch basins. The routine first loops through each unit watershed and makes an estimate of pollutant runoff based on the amount of pollutant on the watershed and the rate

of flow from the watershed. A similar calculation is made through an empirical relationship for each system catch basin. The pollutant runoff estimates are then supplied to subroutine GQUAL for estimates of gutter quality. It should be recognized that because of the assumed proportionality between quality constituents and type of land use it is necessary to route only as many individual items as there are land use categories. This combined routine is later disaggregated into the numerous quality constituents of interest.

Subroutine RECAP

This subroutine, Figure V-13, reads the tapes created by the Runoff Block. It then writes a summary report, either of hydraulic results alone or of hydraulic and quality results, dependent on the specification of the run.

Subroutine RHYDRO

This subroutine is called by HYDRO to read input data related to the subcatchment areas and to perform some initial preparatory work, such as unit conversion and error detection. A normal execution of RHYDRO should provide all the necessary information for the calculation of a runoff hydrograph. Figure V-14 shows the flowchart for subroutine RHYDRO.

There are four basic categories of input data. The general information includes a number representing the subcatchment area, period of simulation, and a key indicating if the rainfall hyetograph is spatially different from that of the previous basin. A new rainfall hyetograph will be read if it is so indicated. Otherwise, that part of the read operation will be skipped and the rainfall of the previous inlet drainage basin will be used. The first basin must have a rainfall input.

The program proceeds to read subcatchment data, e.g., the size, width, ground slope. The gutter information is read soon afterward.

It must be noted that the program can detect only logical errors such as indexing numbers. However, the input data are tabulated by the computer to allow a check against the original for absolute correctness.

Subroutine WSHED

This subroutine computes the depth and flow rate of water overland. The logic of subroutine WSHED can be seen in Figure V-15. As shown in Figure I-7, the subroutine is called by HYDRO at each incremental period of integration. During that period, the rainfall intensity is first interpolated from the designated rainfall hyetograph for each subcatchment. This rainfall intensity is assumed uniform over each subcatchment.

A DO loop is set up to treat the subcatchments, one at a time. For a subcatchment, the amount of infiltration loss is calculated using Horton's equation,

$$\text{Infiltration loss} = f_0 + (f_i - f_0)e^{-\alpha t} \quad (\text{I-13})$$

where f_0 , f_i and α are coefficients and t is the time from the start of rainfall. The loss is compared with the amount of water existing on the subcatchment plus the rainfall. If the loss is larger, it is set equal to the amount available and the remainder of the computation is skipped.

The water depth will thus increase without inducing an outflow until it reaches the specified detention requirement. Beyond that, the outflow rate is calculated by Manning's equation using depth as the hydraulic radius. An iterative procedure using Newton's technique is established to determine the water depth and the outflow rate so that the continuity of water mass is satisfied.

Upon completion, the subroutine will return with a set of water depths on each subcatchment for the next time-step. It also produces the flow necessary for subsequent routing in the gutters.

COMPUTER PROGRAM DESCRIPTION--TRANSPORT BLOCK

The overall logic of the TRANSPORT BLOCK is shown in Figure I-8.

Main Program MAIN

This is the driving or executive program of the Transport Block. In addition, it performs a modified Euler solution of the motion and continuity equations. The necessary data for print requirements is saved by this program. Figure V-16 is a diagram of its logic.

Subroutine BOUND

This subroutine computes the outflow "QOU" for each node. Both internal and external transfers are computed as indicated in Figure V-17.

Subroutine DEPTH

This subroutine finds the critical depth and the normal depth in a conduit, corresponding to a computed flow rate. The procedure is diagrammed in Figure V-18.

Subroutine HEAD

This subroutine converts nodal depths to pipe depths as indicated in Figure V-19. A storage surface area is also assigned to the proper nodes.

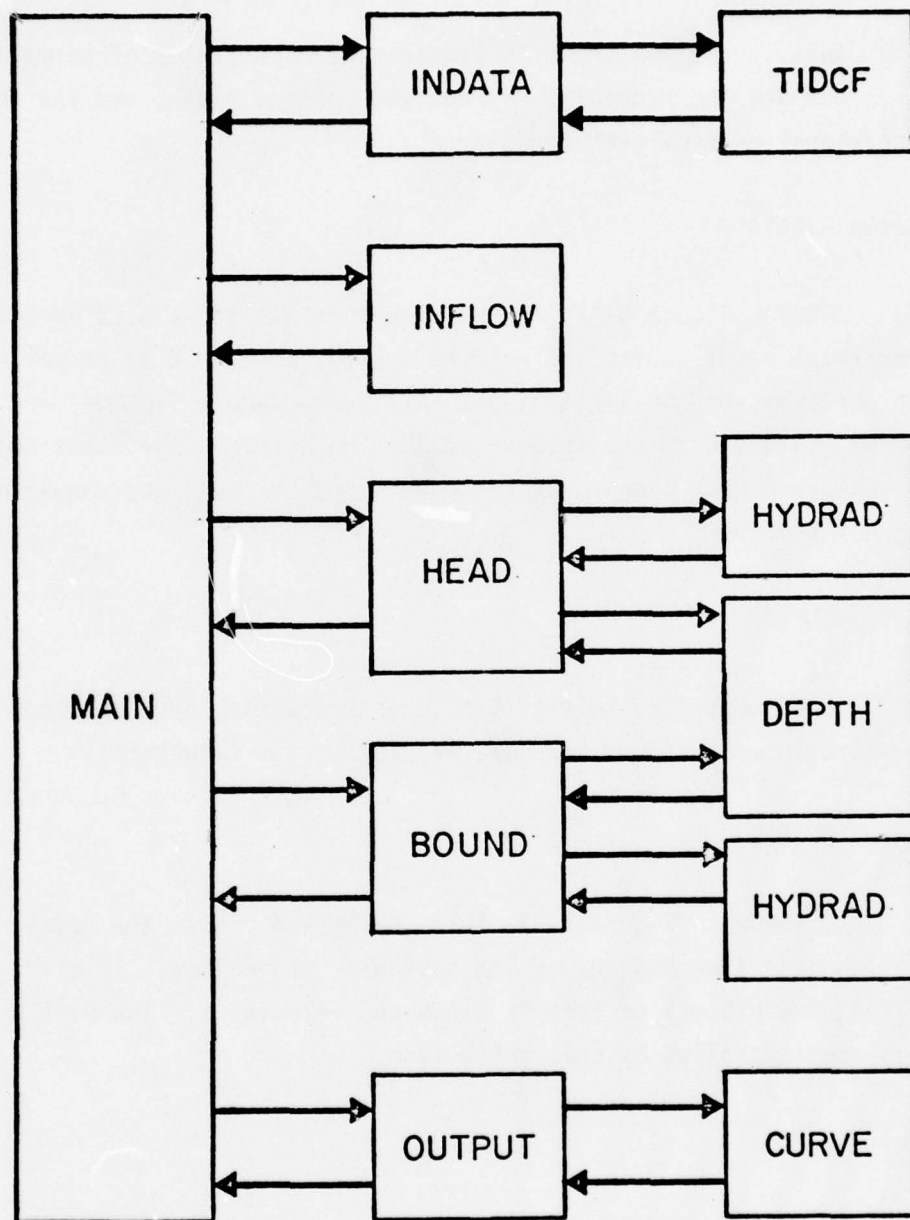


FIGURE I-8 GENERAL STRUCTURE TRANSPORT BLOCK

Subroutine HYDRAD

This subroutine shown in Figure V-20 uses tables of normalized values to compute the hydraulic radius, the surface width, and the "net" cross-sectional area of each conduit.

Subroutine INDATA

INDATA, Figure V-21, reads and prints all input data except for hydrograph cards, which are read by subroutine INFLOW as required. It also performs some initialization. All node-conduit linkages are set up and converted to the interval numbering system. The first two hydrographs from both tape input and card input are read and converted to internal numbers.

Subroutine INFLOW

This subroutine selects the input hydrograph ordinate from tape or card input. Figure V-22 is the appropriate flowchart.

Subroutine OUTPUT

As shown in Figure V-23, this subroutine prints the nodal information as a time history of the hydraulic grade line. It also prints the time history of conduit flows and velocities. The plot routines are controlled by this subroutine.

Subroutine TIDCF

Subroutine TIDCF uses a least-square procedure to calculate the coefficients of the tidal function $H(T) = A_1 + A_2 \sin(T) + A_3 \sin(2T) + A_4 \sin(3T) + A_5 \cos(T) + A_6 \cos(2T) + A_7 \cos(3T)$ from input values of H and T . The logic is shown in Figure V-24.

COMPUTER PROGRAM DESCRIPTION--TRANSPORT QUALITY BLOCK

The overall logic of the Transport Quality Block is shown in Figure I-9.

Main Program MAIN

MAIN, Figure V-25, is the executive routine for the Quality Transport Block. After initialization, the program does a loop with time as the increment. It calls INPUT and computer nodal volumes and the velocity in each conduit. The pump quality changes are then computed, and then the advective transport through conduits. Internal linkage mass transfers are computed, and then all node concentrations are updated. Necessary values are saved for subsequent printing or plotting. After the completion of the requested time steps, subroutine OUTPUT is called and program is completed.

Subroutine HYDRAD

This subroutine performs the same function in this block as it does in the Transport Block. The reader is referred to the Transport Block. The logic is shown in Figure V-20.

Subroutine INDATA

This subroutine, Figure V-26, reads the job description and control parameters. It also reads the node numbers for detailed printing. Initial information from the input tape units is read in. Initial pollutographs and hydrographs are read in, and checks are made for consistency in time step requirements.

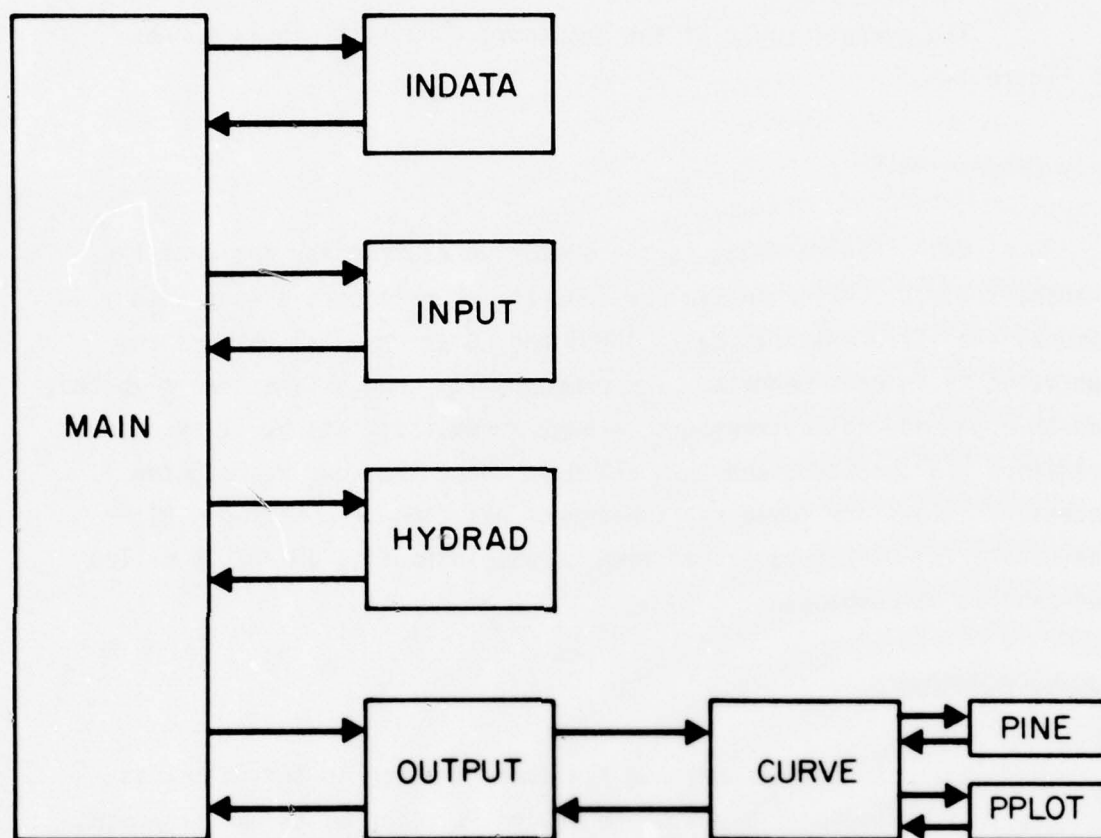


FIGURE I-9 GENERAL STRUCTURE QUALITY TRANSPORT BLOCK

Subroutine INPUT

This subroutine does the necessary interpolation between data points for both quality data and hydraulic data. If new data is required, it is read from the appropriate input tape unit prior to interpolation. The logic is indicated in Figure V-27.

Subroutine OUTPUT

This subroutine processes the stored computed nodal qualities and prints them as shown in Figure V-28.

CHAPTER II

MODEL SPECIFICATIONS

INTRODUCTION

This chapter outlines the specifics of the computer programs as they relate to data preparation and operation on various computer systems. Estimates are given for computer core requirements and peripheral equipment, and estimates of expected execution times.

In the preparation of these computer programs every effort has been made to make them as nonspecific as possible in regard to particular computer systems. However, if problems of program installation develop which cannot be resolved with the use of this document, the program's user is urged to contact Water Resources Engineers, Inc., Walnut Creek, California, for aid in resolving the difficulty.

PROGRAM LANGUAGE

All blocks of the model were originally programmed for the UNIVAC 1108 in FORTRAN V. This version of the FORTRAN compiler is essentially compatible with IBM FORTRAN IV level G and versions of the model have been executed on IBM equipment. This FORTRAN is also compatible with the Extended FORTRAN compiler used on CDC 6000 series equipment.

OPERATING REQUIREMENTS

The model consists of three discrete blocks, each of which has separate operating requirements. The requirements for the Display Block, which is included in the other blocks, are included in the figures given below.

RUNOFF BLOCK

Highspeed core required \approx 126,000₈ words
 \approx 44,000₁₀ words
 \approx 180,000₁₀ bytes
4 drum, disk or tape files: 1 output, 3 scratch

1 card reader
1 line printer

TRANSPORT BLOCK

Highspeed core required \approx 135,000₈ words
 \approx 47,500₁₀ words
 \approx 190,000₁₀ bytes
2 drum, disk or tape files: 1 output
1 input (generated by Runoff Block)

1 card reader
1 line printer

TRANSPORT QUALITY BLOCK

Highspeed core required \approx 126,000₈ words
 \approx 44,000₁₀ words
 \approx 180,000₁₀ bytes

2 drum, disk or tape files: 1 input generated by Runoff Block
1 input generated by Transport Block
1 card reader
1 line printer

TYPICAL EXECUTION TIMES

Typical program execution times for the various program blocks, including the Display Block, are given as follows.

RUNOFF BLOCK

Execution time is approximately proportional to the number of watersheds, gutters and the number of time steps desired. In an example problem involving 50 watersheds, 58 gutters, and 135 time steps, 76 seconds were required on the UNIVAC 1108.

TRANSPORT BLOCK

Execution time is approximately proportional* to the number of conduits and the number of time steps. As an example, a system involving 50 conduits and 40 time steps required 311 seconds on UNIVAC 1108.

TRANSPORT QUALITY BLOCK

Execution time is approximately proportional* to the number of conduits and the number of time steps. As an example, a system involving 7 conduits and 450 time steps required 30 seconds on the UNIVAC 1108.

*Computation is affected to some extent by the volume of printing, hence the relatively long execution time for transport quality.

JOB CONTROL

The assignment of logical units for system I/O requires, in general, the provision for files to be written on specific physical devices. To accomplish this the programmer must supply the necessary job control cards. As a rule, job control is highly machine and installation dependent; in fact, it often differs on two identical machines at different installations. Therefore, the Runoff and Transport Models cannot include a job control definition that is universally applicable.

At most installations the logical unit corresponding to the card reader is given the number 5 and the line printer is given the number 6. The Runoff and Transport Models are programmed on the assumption that units 5 and 6 are so used. Typically, the systems programmers have provided the necessary specification for these units and also for the card punch.

Data file and scratch file assignments require specification to be supplied for each unit. The rules for such assignments must be ascertained from the systems programmers at the installation, since there is considerable variation in unit number availability, etc. In general, one should only set up the units needed in a given run, since there may be a charge for file space that is reserved, even if it is not used.

INPUT/OUTPUT FILES

The total simulation package is designed to be run as separate blocks, with the Display Block used as needed for plotting. Interfacing is accomplished between blocks by magnetic tape, drum or disk storage.

The Runoff Block can create four tapes, two of which, JOUT (1) and JOUT (2), are the hydraulics tape and quality tape respectively for interfacing with the Transport Block and Transport Quality Block. Write statements are unformatted* for these two tapes. The print tape and plot tape are JOUT (3) and JOUT (4), and write statements are formatted.

The Transport Block designates the input hydraulics tape from the Runoff Block as N21. The output hydraulics tape designation is N22. The write statements for N22 are formatted.

The Quality Transport Block designates the input hydraulics tape from the Transport Block as N22 and the quality tape from the Runoff Block as N21.

CARD FORMATS, INPUT DATA

The following tables present the specific card formats required for use of the Runoff Block, the Transport Block and the Transport Quality Block. Table II-1 gives the specifications for the Runoff Block, Table II-2 covers the Transport Block and Table II-3 defines the Transport Quality Block.

The following figures present deck setup schematics for the models: Figure II-1 is a schematic of a complete urban stormwater model deck setup; Figure II-2 is a schematic of a deck setup for the Runoff Block; Figure II-3 is a deck setup schematic for the Transport Block; and Figure II-4 is a deck setup schematic for the Transport Quality Block.

All values should be right justified in the card columns indicated, and the cards should be arranged for input in the same order as described. Unless otherwise noted all cards defined for input must appear in the job input stream.

*Formating is the procedure for placing information on the tapes.

TABLE 11-1
RUNOFF BLOCK CARD DATA

Card Group	Format	Card Columns	Description	Variable Name	Default Value
1	6110	1-10	Name of input tape (none at present).	JIN(1)	None
		11-20	Name of input tape (none at present).	JIN(2)	None
		21-30	Name of quantity output tape.	JOUT(1)	None
		31-40	Name of quality output tape.	JOUT(2)	None
		41-50	Name of print file tape.	JOUT(3)	None
		51-60	Name of plot file tape.	JOUT(4)	None
2	20A4	1-80	Title cards: two cards with heading to be printed on output.	TITLE	None
3			Control card: one card.		
	2I5	1- 5	Number of Basin.	INLET	None
		6-10	Number of time-steps to be calculated.	NSTEP	None
	I3	11-13	Hour of start of storm (24-hour clock).	NHR	None
	I2	14-15	Minutes of start of storm.	NMN	None
	F5.1	16-20	Integration period (min).	DELT	None
	I5	21-25	Number of hyetographs.	NRGAG	None
	F5.Q	26-30	Percent of impervious area with zero detention (immediate runoff).	PCTZER	25.0
4			Rainfall control card.		
	I5	1- 5	Number of data points for each hyetograph.	NHISTO	None
	F5.0	6-10	Time interval between values (min). (Must be even multiple of DELT above)	THISTO	None
5			REPEAT CARD GROUP 5 FOR EACH HYETOGRAPH.		
			Rainfall hyetograph cards: 10 intervals per card.		
	10F5.0	1- 5	Rainfall intensity, first interval (in./hr.).	RAIN(1)	None
		6-10	Rainfall intensity, second interval (in./hr.).	RAIN(2)	None
		11-15	Rainfall intensity, third interval (in./hr.).	RAIN(3)	None
		16-20	Rainfall intensity, fourth interval (in./hr.).	RAIN(4)	None
		⋮		⋮	
		⋮		⋮	

TABLE 11-1
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
REPEAT CARD 6 FOR EACH GUTTER/PIPE.					
6			Gutter/pipe cards: one card per gutter/pipe (if none, leave out).		
	216	1- 6	Gutter number.	NAMEG	None
		7-12	Gutter or Inlet number for drainage.*	NGTO	None
	13	13-15	(= 1 for gutter = 2 for pipe	NP	None
	5X	16-20	Blank		
	7F8.0	21-28	Bottom width of gutter or pipe diameter (ft).	GWIDTH=G1	None
		29-36	Length of gutter (ft).	GLEN =G2	None
		37-44	Invert slope (ft/ft).	GSLOPE=G3	None
		45-52	Left-hand slope (ft/ft). horizontal/ vertical	GS1 =G4	None
		53-60	Right-hand slope (ft/ft). horizontal/ vertical	GS2 =G5	None
		61-68	Manning's coefficient.	GN =G6	None
		69-76	Depth of gutter when full (in).	DFULL =G7	10. in.
NOTE: Blank card to terminate gutter cards: one card.					
REPEAT CARD 7 FOR EACH SUBCATCHMENT.					
7			Subcatchment cards (216, 13, 10F5.0, F10.5): one card per subcatchment.		
	216	1- 6	Subcatchment number.	NAMEW	None
		7-12	Gutter or inlet number for drainage.	NGTO	None
	I-3	13-15	Hyetograph number.	NHYET=JK	None
	10F5.0	16-20	Width of subcatchment (ft).	WWIDTH=W1	None
		21-25	Area of subcatchment (acres).	WAREA =W2	None
		26-30	Percent imperviousness of subcatchment.	PCIMP =W3	None
		31-35	Ground slope (ft/ft).	WSLOPE=W4	0.030
		36-40	Impervious area	W5 =W5	0.013
		41-45	Pervious area } Resistance Factor	W6 =W6	0.250
		46-50	Impervious area	WSTORE=W7	0.062
		51-55	Pervious area } Retention storage (in.)	WSTORE=W8	0.184

*Gutter or inlet to which gutter drains.

TABLE 11-1
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
7	10F5.0 (cont'd)	56-60	Maximum infiltration rate (in./hr.).	WLMAX=W9	3.00
		61-65	Minimum infiltration rate (in./hr.).	WLMIN=W10	0.52
	F10.5	66-75	Decay rate of infiltration (1/sec).	DECAY=W11	0.00115
	F5.0	75-80	Maximum allowable infiltration (inches).	DEPIN=W12	12.inches
NOTE:			Blank card to terminate subcatchment cards: one card.		
8	I10	1-10	Number of quality constituents.	NQS	None
	2E10.0	11-20	Number of dry days since last precipitation	DRYDAY	None
		21-30	Street cleaning frequency (days).	CLFREQ	None
	I10	31-40	Number of passes per cleaning.	NPASS	None
	E10.0	41-50	Catchbasin volume (cubic feet).	CBVOL	None
			OPTIONAL CARDS, SKIP IF NQ's ON CARD GROUP 8 ABOVE IS ZERO		
9	REPEAT CARD GROUP 9 FOR EACH SUBCATCHMENT.				
	2I10	1-10	Subcatchment number.	N	None
		11-20	Land use type. =1 for single family residential =2 for multi-family residential =3 for commercial =4 for industrial =5 for undeveloped or park lands.	KLAND=KL	None
	2E10.0	21-30	Number of feet of gutter in subcatchments.	GQLEN= GQ(100 FT)	None
		31-40	Equivalent number of standard catchbasins.	BASINS=BA	None
10	Inlet/gutter print control: one card.				
	2I5	1- 5	Number of inlets/gutters for which flows are to be printed.	NPRNT	None
		6-10	Number of time-steps between printings.	INTERV	None
11	IF NPRNT=0, SKIP CARDS 11.				
	Inlet/Gutter print cards: 16 values per card.				
	16I5	1-5	Inlet/Gutter numbers for which flows are to be printed.	IPRNT(1)	None
		6-10	(Maximum of 200)	IPRNT(2)	None
	11-15		IPRNT(3)	None	
	.		.		
	.		.		
	.		.		
	.		.		
	.		IPRNT(NPRNT)	None	

TABLE II-1
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
12	15	1-5	Number of gutter and inlets to be plotted.	NPLOT	None
13			If NPLOT=0, SKIP CARDS 13 and 14 Gutter and inlet plot cards: 16 values per card.		
	1615	1-5	Inlets and gutters which are to be plotted.	IPLOT(1)	None
		6-10		IPLOT(2)1	None
		11-15		IPLOT(3)	None
		.		.	
		.		.	
		.		.	
		.		IPLOT(NPLOT)	None
14			Constituents to be plotted, 0 means no plot, 1 means plot.		
	2511				
		1	Flow	None	None
		2	Settleable Solids	None	None
		3	Suspended Solids	None	None
		4	Total Dissolved Solids	None	None
		5	BOD	None	None
		6	COD	None	None
		7	Chlorides	None	None
		8	SO ₄	None	None
		9	Grease	None	None
		10	Total Coliform	None	None
		11	Fecal Coliform	None	None
		12	Ammonia	None	None
		13	Organic N	None	None
		14	Nitrate plus nitrite	None	None
		15	Total hydrolyzed phosphorous	None	None
		16	Orthophosphate	None	None
		17	Mercury	None	None
		18	Copper	None	None
		19	Zinc	None	None
		20	Lead	None	None
		21	Chromium	None	None
		22	Cadmium	None	None
		23	Arsenic	None	None

NOTE: The arrangement of constituents to be plotted will apply to all gutters and inlets. No changes can be made between plots.

TABLE II-2
TRANSPORT BLOCK PROGRAM DATA

Card Group	Format	Card Columns	Description	Variable Name	Default Value
1	15A4	1-60	Description of computer run, will be printed on output. (2 cards).	ALPHA	None
2	15, 2F5.0, 8I5, 4X, A6, 15	1-5	Number of integration steps or time cycles desired.*	NTCYC	None
		6-10	Length of integration step, seconds.	DELT	0.0
		11-13	Start time, hours.	NHR	0
		14-15	Start time, minutes	NMN	0
		16-20	Number of nodes for detailed printed information for each cycle (20 maximum)	NHPRT	None
		21-25	Number of conduits for detailed printed information for each cycle (20 maximum)	NQPRT	None
		26-30	Number of nodes to be plotted (18 maximum)	NPLT	None
		31-35	Number of conduit flows to be plotted (18 maximum).	LPLT	None
		36-40	Start print cycle	NSTART	1
		41-45	Interval between print cycles (maximum number of cycles printed is 100, \therefore $\frac{NTCYC - NSTART}{INTER} < 100$)	INTER	1
		46-50	Number of input nodes, if card input hydrographs are used.	NJSW	None
		51-55	Hydrograph input tape	N21	0
		60-65	Name of saved hydrograph input file (N21)	NAME	None
		66-70	Quality input tape	N22	0
3	8I10	1-10	First node number for detailed printing	JPRT (1)	None
		11-20	Second node number, up to number of nodes defined by NHPRT.	JPRT (2)	None

*Suggested for initial simulation run.

$$NTCYC = \frac{(NSTEP \times DELT) \text{ of runoff block} \times 60 \text{ sec. per min.}}{DELT \text{ of transport block}}$$

TABLE II-2
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
4	8I10	1-10	First conduit number for detailed printing.	CPRT (1)	None
		11-20	Second conduit number up to number of nodes defined by NQPRT.	CPRT (2)	None
<u>(FOR ELEVATIONS AND/OR FLOWS)</u>				<u>OPTIONAL</u>	
5	8I10	1-10	First node number for plotting	JPLT (1)	None
		11-20	Second node number, up to number of nodes defined by NPLT. (This option is for junction on water surface elevations)	JPLT (2)	None
6	8I10	1-10	First conduit number for plotting	KPLT (1)	None
		11-20	Second conduit number for plotting, up to number of nodes defined by LPLT (This option is for conduit flow rate).	KPLT (2)	None
1 CARD/CONDUIT					
7	4I5, 7F5.0	1-5	Conduit number	NCOND (N)	None
		6-10	Node number at one end of conduit upstream	NJUNC(N,1)	None
		11-15	Node number at other end of conduit downstream	NJUNC(N,2)	None
		16-20	Type of conduit shape 1 = circular 2 = rectangular 3 = horseshoe 4 = egg 5 = baskethandle 6 = trapezoid (Open Channel)	NKCLASS(N)	None
		21-25	Cross sectional area of conduit, Sq. Ft. (necessary only for types 3,4, and 5).	AFULL (N)	None
		26-30	Vertical depth of conduit, feet	DEEP (N)	None
		31-35	Maximum width of conduit, feet (for Trapezoid, Bottom Width; for Pipe, Dia.)	WIDE (N)	0.0
		36-40	Length of conduit, feet	LEN (N)	None
		41-45	Distance of conduit invert above node invert at NJUNC (N,1) (upstream)	ZP (N,1)	0.0

TABLE II-2
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
7 (Con't)	4I5, 7F5.0	46-50	Distance of conduit invert above node invert at NJUNC (N,2) (downstream)	ZP (N,2)	None
		51-55	Mannings coefficient	ROUGH (N)	0.014
		66-70	Slope on one trapezoid side (horizontal/vertical)	STHETA (N)	0.0
		71-75	Slope on other trapezoid side (horizontal/vertical)	SPHI (N)	0.0
(Last card must have 99999 in columns 1 to 5)					
1 CARD/NODE					
8	15, 3F5.0	1-5	Node number (none greater than 9999).	JUN (J)	None
		6-10	Ground elevation, feet.	GRELEV (J)	0.0
		11-15	Invert elevation, feet.	Z (J)	0.0
		16-20	Net constant flow into nodes, cfs (optional)	QINST (J)	0.0
(Last card must have a 99999 in columns 1 to 5)					
1 CARD/ORIFICE					
9	2I5, 2F5.0	1-5	Junction containing orifice.	NJUNC (N,1)	None
		6-10	Junction to which orifice discharges	NJUNC (N,2)	None
		11-15	Orifice area in sq. ft.	AORIF (I)	0.0
		16-20	Orifice discharge coefficient.	CORIF (I)	0.0
(Last card must have 99999 in columns 1 to 5)					
1 CARD/WEIR					
10	3I5, 5F5.0	1-5	Node at which weir is located.	NJUNC (N,1)	None
		6-10	Conduit to which weir discharges (NOTE: If free outfall weir, set NJUNC (N,2) equal to zero).	NJUNC (N,2)	None

TABLE II-2
(Continued)

Group	Format	Columns	Description	Variable Name	Default Value
10 (Con't)	3I5 5F5.0	11-15	Type of weir 1. transverse 2. transverse with tide gates 3. side flow 4. side flow with tide gates	KWEIR (I)	None
		16-20	Height of weir above invert, feet.	YCREST (I)	0.0
		21-25	Height to top of weir opening, above invert, feet.	YTOP (I)	0.0
		26-30	Weir length, feet.	WLEN (I)	0.0
		31-35	Coefficient of discharge for weir.	COEF (I)	0.0
		36-40	Coefficient of discharge for surcharged condition.	COEFS (I)	0.0
(Last card must have a 99999 in columns 1 to 5)					
1 CARD/PUMP					
11	2I5, 7F5.0	1-5	Node being pumped	NJUNC (N,1)	None
		6-10	Pump flow goes to this node.	NJUNC (N,2)	None
		11-15	Initial wet well volume, cu. ft.	VWELL (I)	0.0
		16-20	Lower pumping rate, cfs.	PRATE (I,1)	0.0
		21-25	Mid pumping rate, cfs.	PRATE (I,2)	0.0
		26-30	High pumping rate, cfs.	PRATE (I,3)	0.0
		31-35	Wet well volume for mid rate pumps to start, cu. ft.	VRATE (I,1)	0.0
		36-40	Wet well volume for high rate pumps to start pumping, cu. ft.	VRATE (I,2)	0.0
		41-45	Total well volume, cu.ft.	VRATE (I,3)	0.0
(Last card must have 99999 in columns 1 to 5)					
1 CARD/FREE OUTFALL*					
12	15	1-5	Node for free outfall. *Only one connecting conduit (Link) is permitted to a free outfall node	JFREE (I)	None
(Last card must have 99999 in columns 1 - 5)					

TABLE II-2
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
1 CARD/NON-WEIR TIDE GATE					
13	I5	1-5	Node at which gate is located (Last card must have a 99999 in column 1-5)	JGATE (1)	None
14	I5, 7F10.0, 1-5 F5.0	1	no water surface at outfalls	NTIDE	None
		2	outfall control water surface at constant elevation, A 1		
		3	tide coefficients provided		
		4	program will compute tide coefficients		
		6-10	First tide coefficient	A 1	0.0
		11-15	Second tide coefficients	A 2	0.0
		16-20	Third tide coefficient	A 3	0.0
		21-25	Fourth tide coefficient	A 4	0.0
		26-30	Fifth tide coefficient	A 5	0.0
		31-35	Sixth tide coefficient	A 6	0.0
		36-40	Seventh tide coefficient	A 7	0.0
		41-45	Tidal period in hours	W	0.0
REQUIRED IF NTIDE = 4					
15	3I5	1-5	If one, there are four information points, program will develop tide coefficients.	K0	None
		6-10	Number of information points (4 if K0 above equals 1).	NI	None
		11-15	If one, will print information on tide coefficient development.	NCHTID	0
REQUIRED IF NTIDE = 4					
16	8F10.0	1-10	Time, first information points.	TT (1)	0.0
		11-20	Tidal stage, at time above.	YY (1)	0.0
		21-30	Time, second information points.	TT (2)	0.0
		31-40	Tidal stage, at time above, up to number of points as defined by <u>NI</u> .	YY (2)	0.0

TABLE II-2
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
Required if NJSW≥1 (in Card Group 2)					
17	1615	1-5	First input node for card hydrograph	JSW (1)	None
		6-10	Second input node for card hydrograph, up to <u>NJSW</u> nodes.	JSW (2)	None
18	8F10.0	1-10	Initial dry weather flows (cfs)	Q(1)	None
		11-20	Initial dry weather velocities (fps)	V(1)	None
		21-30		Q(2)	None
		31-40		V(2)	None
		41- .		.	
		:		:	
		:		:	
		(4 conduits per card, up to NTC conduits. Includes internal links.)		Q(NTC)	None
		V(NTC)	None		
19	8F10.0	1-10	Initial dry weather heads (ft)	Y(1)	None
		11-20		Y(2)	None
				.	
				.	
				.	
				Y(NJ)	None
Required if NJSW≥1 (in Card Group 2)					
20	8F10.0	1-10	Time, referenced to start time, hours (decimal).	TE0	0.0
		11-20	Flow rate, cfs., first input node, JSW (1).	QCARD (L,1)	0.0
		21-30	Flow rate, cfs., second input node, JSW (2), up to <u>NJSW</u> nodes.	QCARD (L,2)	0.0
(Repeat group 20 cards, final time on last group 20 card must be greater than end time of run).					

TABLE II-3
TRANSPORT QUALITY BLOCK CARD DATA

Card Group	Format	Card Columns	Description	Variable Name	Default Value
1	15A4	1-60	(Two cards) Title cards	BETA	None
2*	I5	1-5	Number of integration cycles	NQCYC	None
	2F5.0	6-10	Length of integration step (seconds)	DELT	None
		11-13	Start time (hours)	NHR	None
		14-15	Start time (minutes)	MIN	None
	4I5	16-20	Number of nodes for detailed printout (20 maximum)	NPRNT	None
		21-25	Cycle for start of printing	NSTART	None
		26-30	Interval between printing cycles	INTER	None
		31-35	Quality input tape	N21	None
	A6	40-45	Not used at this time	NAMER	
	I5	46-50	Hydraulic input tape	N22	None
	A6	55-60	Not used at this time	NAMES	
	I5	61-65	Number of nodes for printer plot	NPLOT	None
If NPRNT = 0, skip cards 3 and 4					
3	8I10	1-10	Node numbers for detailed printout (maximum of 20)	JQPRT(1)	None
		11-20		JQPRT(2)	None
		21-30		JQPRT(3)	None
		⋮			
		⋮		JQPRT(NPRNT)	None
4			Constituents to be printed, 0 means no plot, 1 means plot.		
	25I1	1	Ignored	ICODL(1)	None
		2	Settleable Solids	ICODL(2)	None
		3	Suspended Solids	ICODL(3)	None
		4	Total Dissolved Solids	ICODL(4)	None

*To be same as Transport Block

TABLE II-3
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
4 (Continued)					
		5	BOD	ICODL(5)	None
		6	COD	ICODL(6)	None
		7	Chlorides	ICODL(7)	None
		8	SO ₄	ICODL(8)	None
		9	Grease	ICODL(9)	None
		10	Total Coliform	ICODL(10)	None
		11	Fecal Coliform	ICODL(11)	None
		12	Ammonia	ICODL(12)	None
		13	Organic N	ICODL(13)	None
		14	Nitrate plus nitrite	ICODL(14)	None
		15	Total hydrolyzed phosphorous	ICODL(15)	None
		16	Orthophosphate	ICODL(16)	None
		17	Mercury	ICODL(17)	None
		18	Copper	ICODL(18)	None
		19	Zinc	ICODL(19)	None
		20	Lead	ICODL(20)	None
		21	Chromium	ICODL(21)	None
		22	Cadmium	ICODL(22)	None
		23	Arsenic	ICODL(23)	None
NOTE: The arrangement of constituents to be printed will apply to all junctions. No changes can be made between plots.					

5		If NPLOT=0, skip cards 5 and 6			
		Junction cards: 8 values per card			
1615	1-10	Junctions which are to be plotted	JQPRT (NPRNT+1)	None	

TABLE II-3
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
5 (Continued)					
		11-20		JQPRT(NPRNT+2)	None
		21-30		JQPRT(NPRNT+3)	None
		:		:	
		:		:	
		:		JQPRNT(NPRNT+NPLT)	None
6					
			Constituents to be plotted, 0 means no plot, 1 means plot.		
2511		1	Flow	ICODE(1)	None
		2	Settleable Solids	ICODE(2)	None
		3	Suspended Solids	ICODE(3)	None
		4	Total Dissolved Solids	ICODE(4)	None
		5	BOD	ICODE(5)	None
		6	COD	ICODE(6)	None
		7	Chlorides	ICODE(7)	None
		8	SO ₄	ICODE(8)	None
		9	Grease	ICODE(9)	None
		10	Total Coliform	ICODE(10)	None
		11	Fecal Coliform	ICODE(11)	None
		12	Ammonia	ICODE(12)	None
		13	Organic N	ICODE(13)	None
		14	Nitrate plus nitrite	ICODE(14)	None
		15	Total hydrolyzed phosphorous	ICODE(15)	None
		16	Orthophosphate	ICODE(16)	None
		17	Mercury	ICODE(17)	None
		18	Copper	ICODE(18)	None
		19	Zinc	ICODE(19)	None

TABLE II-3
(Continued)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
6 (Continued)					
		20	Lead	ICODE(20)	None
		21	Chromium	ICODE(21)	None
		22	Cadmium	ICODE(22)	None
		23	Arsenic	ICODE(23)	None

NOTE: The arrangement of constituents to be
plotted will apply to all junctions.
No changes can be made between plots.

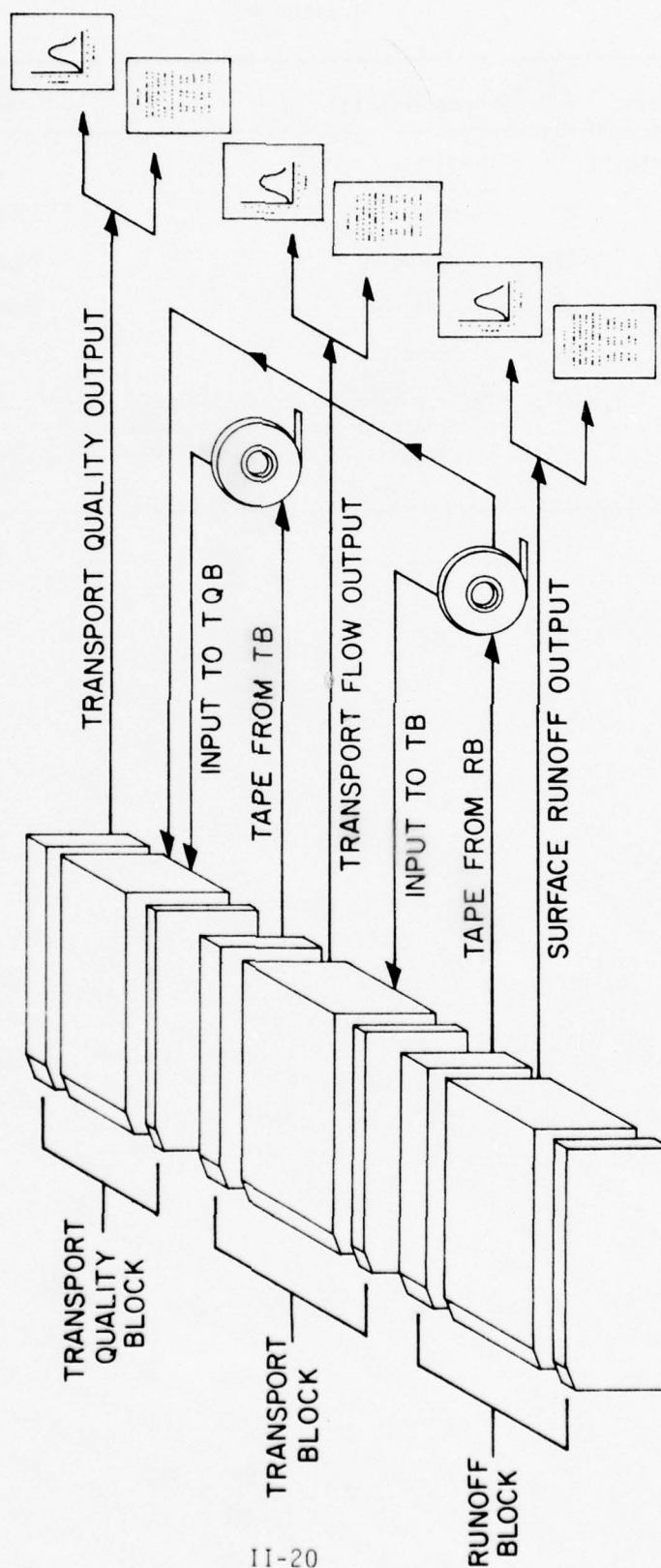


FIGURE II-1. SCHEMATIC OF URBAN STORMWATER SETUP DECK

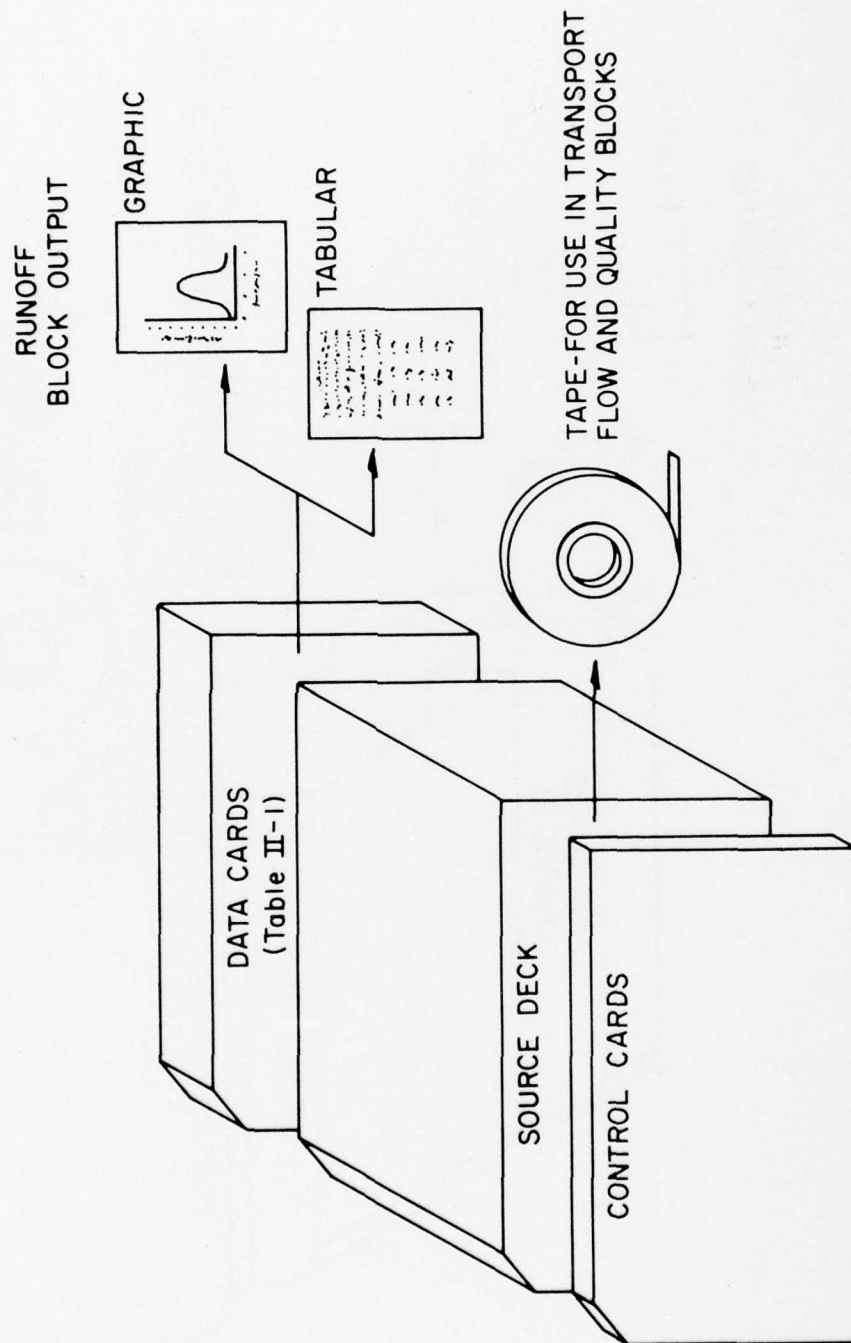


FIGURE II-2. SCHEMATIC OF RUNOFF BLOCK SETUP DECK

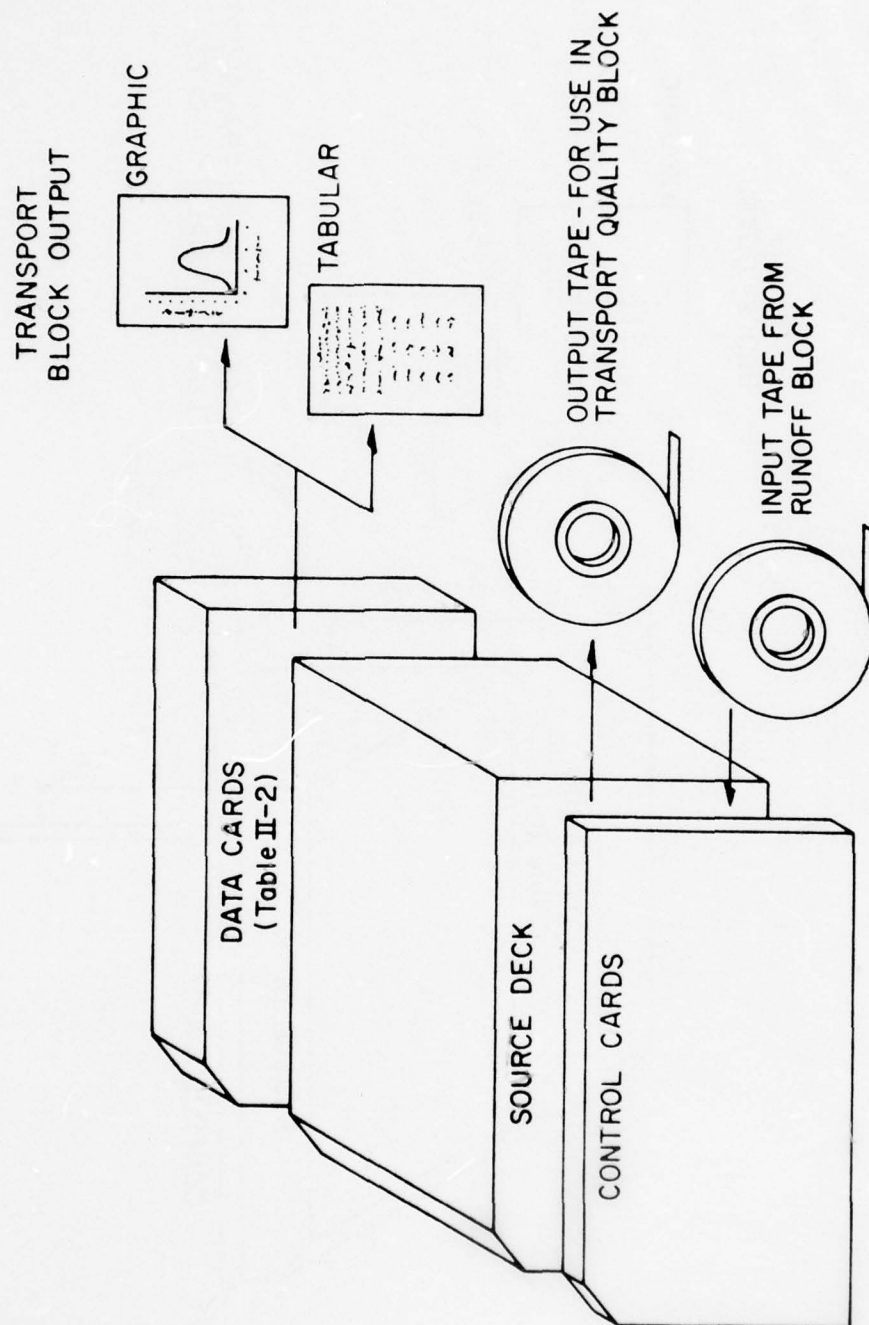


FIGURE II-3. SCHEMATIC OF TRANSPORT BLOCK SETUP DECK

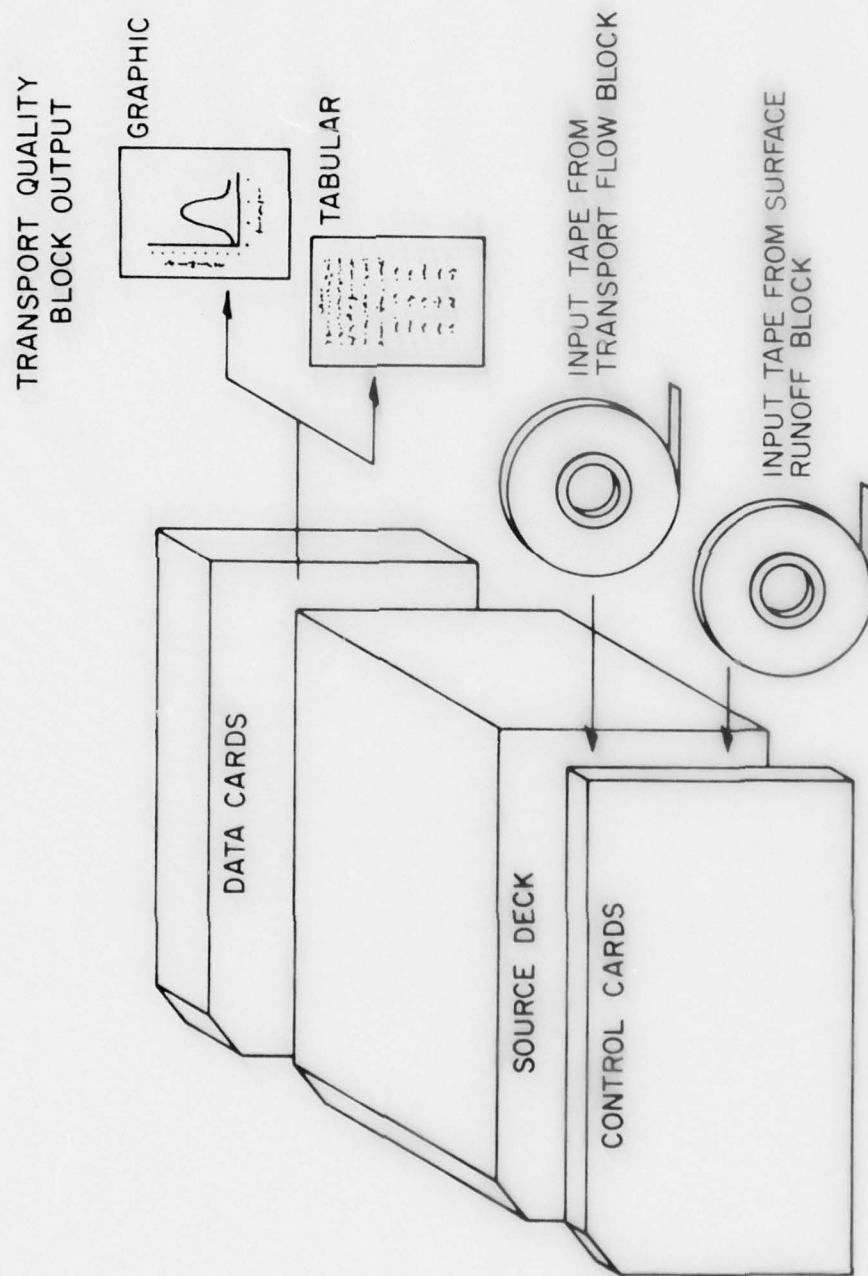


FIGURE II-4. SCHEMATIC OF TRANSPORT QUALITY BLOCK SETUP DECK

CHAPTER III

EXAMPLES OF PROGRAM APPLICATION

INTRODUCTION

Two example problems are presented in this chapter to provide the reader with a reference to an actual program application. The first example, Example A, shows the complete simulation of a typical area in the Seattle vicinity, the South Seattle Industrial Park. This problem demonstrates the majority of problems which one encounters in the application of the models and is explained in its entirety with full reproduction of the data used for input and the computer produced results.

The second problem, Example B, is also fully presented and is an extension of the first problem in that it covers the situation encountered during surface flooding. This important problem has been of considerable concern in the development of these models, and it is intended that this example clear up any remaining questions regarding the manner in which this problem should be handled.

Any potential user of the models described in this report is urged to study these example problems fully. By following carefully the procedure set forth in the examples many questions will be answered and the problem of "How do I get started?" should be resolved. Obviously questions will arise which are not included in these examples, but a good understanding here will go a long way toward easing the startup pains often encountered in the use of computer programs as intricate and comprehensive as those provided here.

As a further aid to understanding both the models in general and the example problems in particular, the reader is referred to Figure III-1 which is an overview of a complete urban drainage system. While this representation contains more elements than the models can accommodate, one should be able to locate the areas to which the various model blocks are applicable. The Runoff Block would be used in the catchment and overland flow areas of the drainage system and would be used to transform specified rainfall patterns into expected hydrographs at locations on the surface system. Normally no pressure or confined flow would be included in this description, and quality would be determined from the characteristics of the watershed.

The Transport and Transport Quality Blocks would be used to extend the routing of the surface hydrographs into the surface sewer system and ultimately to the treatment or overflow facilities. The sewer system could be expected to flow under both free surface and pressure conditions and would have a number of control structures and overflow features not found in overland flow. Momentum and backwater effects are assumed to have more significance in the routing of the Transport Block, and this model should be used wherever these effects are expected to dominate as compared to the kinematic wave effects formulated into the Runoff Block.

APPLICATION TO A TYPICAL URBAN WATERSHED

The example problem is taken from a small urban watershed known as the South Seattle Industrial Park. This area, which is a little over 27 acres in size, is representative of a number of watersheds in the Seattle area and is also one of the model calibration watersheds. Figure III-2 shows the basic topography of the area, and the necessary layout for both the Runoff and Transport Blocks have been included on the figure. The modeling elements associated with the Runoff Model

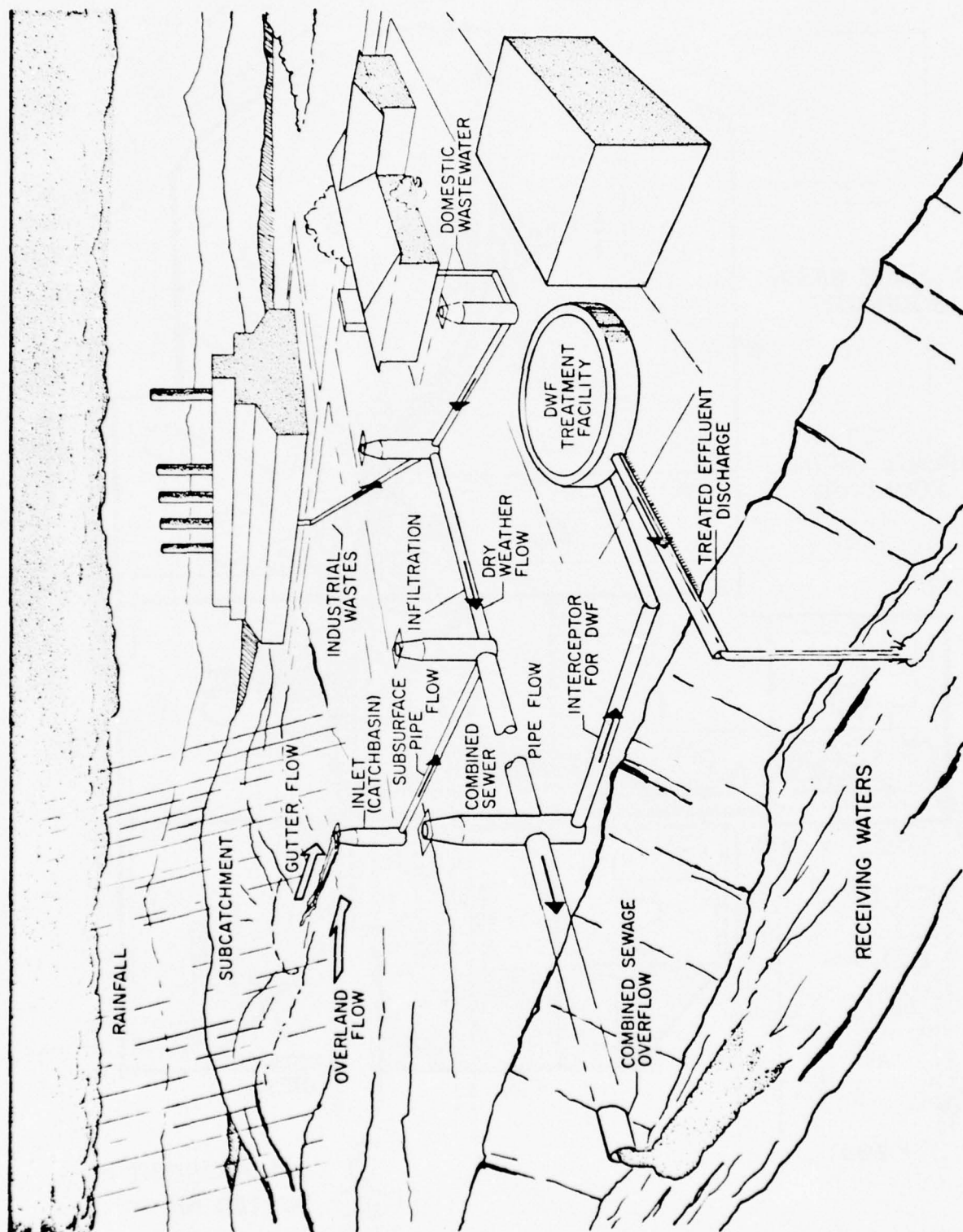


FIGURE III-1 URBAN DRAINAGE SYSTEM REPRESENTATION

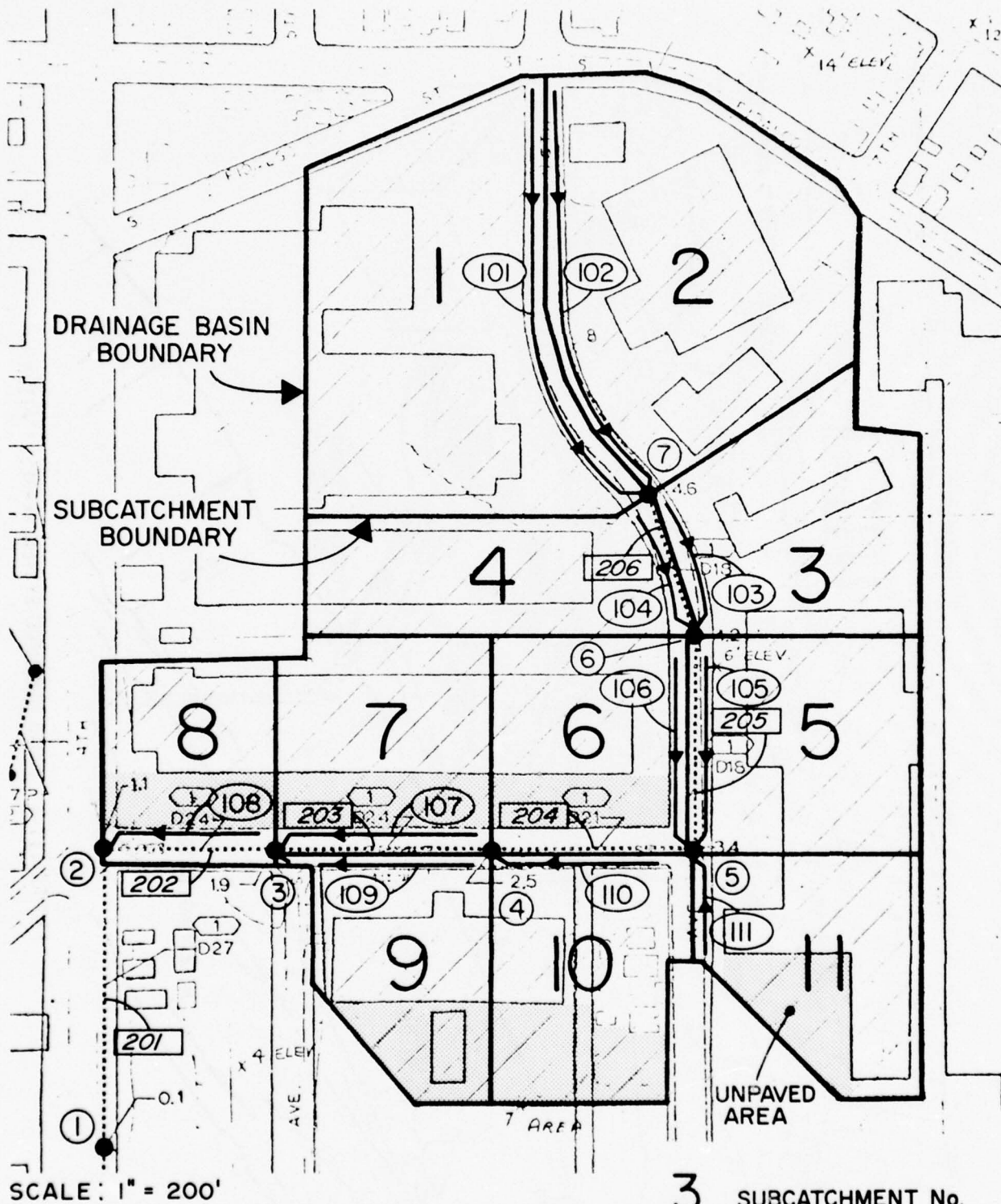


FIGURE III-2 EXAMPLE PROBLEM
SOUTH SEATTLE INDUSTRIAL PARK

are the subcatchments and gutters, while the Transport system features are the conduits and junctions.

The example problem is presented by first giving a general narrative description of the data and parameters which must be supplied to both the Runoff and Transport Blocks and then by indicating the specific values chosen for the example problem. To the extent possible the initial narrative description has been made general and most comments are applicable to problems beyond those of this specific example.

SETUP OF RUNOFF BLOCK

Use of the surface flows portion of the Runoff Block requires three basic steps:

- Step 1 - Geometric representation of the drainage basin
- Step 2 - Estimate of coefficients
- Step 3 - Preparation of data cards for the computer program

Method of Discretization

Discretization is a procedure for the mathematical abstraction of the physical drainage system. For the computation of hydrographs the drainage basin may be conceptually represented by a network of hydraulic elements, i.e., subcatchments, gutters, and pipes. Hydraulic properties of each element are then characterized by various parameters, such as size, slope, and roughness coefficient.

Discretization begins with the identification of the drainage basin boundary, the location of major inlets, and the selection of those gutters/pipes to be included in the runoff model system. This is best shown by an example. Figure III-2 shows the discretization of the South Seattle Industrial Park calibration drainage area which is tributary to

a sampling manhole, junction 1. The Transport Block is used for the conduit system in this sample problem with hydrographs and pollutographs at inlets to the conduit system being generated by the Runoff Block.

It is obvious that judgment must be exercised in setting up the problems as far as determining that portion of the drainage system that can best be represented by either the Runoff or the Transport Block. The desired form of the results usually indicates which model should be used for which portions of a drainage system. If the objective is that of a reconnaissance level analysis of a drainage system and/or the impact on the system of alternative land use patterns, then the Runoff Block can be used exclusively to represent the entire drainage system. For a detailed analysis of the conduit drainage system, a greater portion of the system should be represented by the Transport Block. If backwater effects are significant or if hydraulic elements other than conduits and gutters, such as weirs, are used, then the Transport Block must be used.

Subcatchments or unit watersheds are idealized rectangular areas with uniform slope and groundcover, i.e. asphalt, concrete, or turf. Each subcatchment has unique properties in terms of slope and groundcover. Thus, the roof of a house may be represented by two subcatchments because the water drains in two different directions, even though both units have the same groundcover and absolute ground slope. Likewise, bare dirt and pavement can be treated separately because of the difference in groundcover.

While the subdivision of any area can be taken to infinitesimal detail in theory, computation time, data, and manpower requirements impose real limitations in practice. No ready rule for the subdivision can be offered, but if detailed analysis of the results is desired, then corresponding detail of representation of the drainage basin should be undertaken. The runoff from a basin responds more quickly with respect to changes in rainfall intensities as the representation of the basin is made more detailed.

Estimate of Coefficients

Coefficients and parameters necessary to characterize the hydraulic properties of a subcatchment include surface area, width, percent imperviousness, ground slope, roughness coefficient, detention depth, infiltration rate, and soil infiltration capacity. Since real subcatchments are not rectangular areas experiencing uniform overland flow, average values must be selected for computation purposes.

For the roughness coefficient, one can use the values given in Table III-1, as suggested by Crawford and Linsley. Detention depths are taken by the program as 1/16th-inch for impervious areas and 1/4-inch for pervious areas, unless specified at other values by the user. The infiltration rate can be specified by the user from field test data or estimated from "standard infiltration capacity curves" shown in Figure III-3, which was produced by the American Society of Civil Engineers (ASCE). A limit on the amount of rainfall that can infiltrate into the soil can be placed on the pervious areas by specifying the maximum infiltration amount in inches. Twelve inches is used unless specified otherwise by the user. Resistance factors for the pervious and impervious parts of a subcatchment are specified separately with default values of .250 and .013 (Manning's n for overland flow) being taken in the absence of other information.

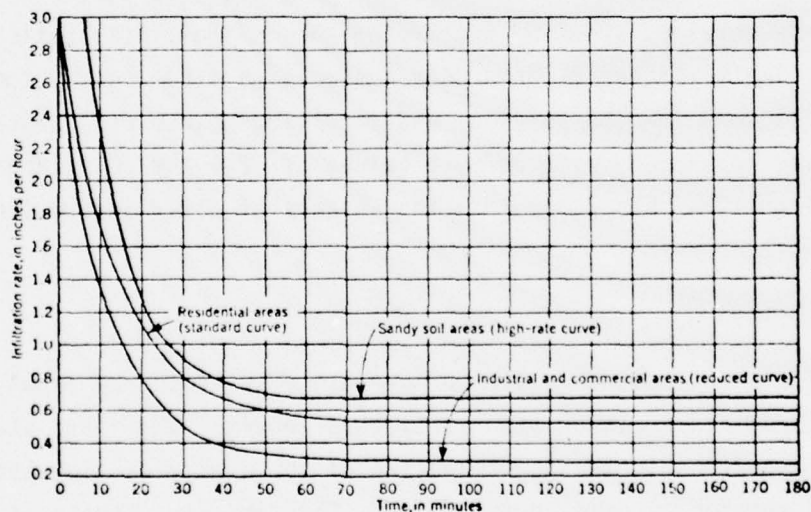
Data Card Preparation

The data cards should be prepared according to the input data card formats presented in Chapter II of this report. The first step in the data preparation is the determination of the number of time-steps to be used and the length of each time-step. The time-step length is usually 2 minutes but may range from 1 to 30 minutes, depending on the length and intensity of storm and the degree of accuracy required. The time of simulation should extend past the storm termination sufficiently to account for the routing of storm runoff. Along with the input of time-steps, the number of unique hyetographs for the drainage basin is needed.

TABLE III-1 ESTIMATE OF MANNING'S ROUGHNESS COEFFICIENTS

Ground Cover	Manning's n for Overland Flow
Smooth asphalt	0.012
Asphalt or concrete paving	0.014
Packed clay	0.03
Light turf	0.20
Dense turf	0.35
Dense shrubbery and forest litter	0.4

Source: N. H. Crawford and R. K. Linsley, "Digital Simulation in Hydrology, Stanford Watershed Model IV".



Source: American Society of Civil Engineers, Manual of Engineering Practice No. 37, 1960.

FIGURE III-3 STANDARD INFILTRATION-CAPACITY CURVES FOR PERVIOUS SURFACE

The rainfall data cards are then prepared for each hyetograph from rainfall records or are assumed if a hypothetical test case is being run. The time interval for rainfall input need not be the same as in the flow and quality portion of the model, although the computation time step and the rainfall interval should be even multiples of each other. The major effort in data preparation is forming a tree-shaped structure drainage system and dividing the drainage basin into subcatchments. The drainage system data is obtained from available maps. Pipes smaller than 2-3 feet with no backwater effects, flow dividers, or lift stations are usually designated as gutter/pipes for computation by the Runoff Block. These pipes are not connected to one another by manholes but join directly and lead to an inlet for further routing by the Transport model. Once the drainage system is labeled with numbers (see Figure III-2), the subcatchment areas are formed reflecting the existing drainage system, ground cover, and land slope. Data cards are then made up for each numbered subcatchment, defined by its width, area, slope, percent imperviousness, etc., along with the gutter/pipe or inlet into which the flows are routed. Next, the gutter/pipe cards are prepared giving the required information.

Surface Quality

Data to simulate surface quality are prepared at the same time as the rest of the Runoff model. Thus when a drainage basin is selected, it should be subdivided into subcatchments containing a single type of land use. Five land uses which may be modeled are: single family, residential, multi-family residential, commercial, industrial, and undeveloped or parklands.

The program may be used with runoff from a design storm or an actual storm. If an actual storm is being modeled, the number of dry days prior to that storm is determined from rainfall records. Otherwise, the number of dry days is part of the information associated with a design

storm. In determining dry days from actual storms the real number of continuous antecedent days without rainfall should be increased to allow for residual surface solids from the earlier storms. A suggested starting estimate for dry days is the total consecutive antecedent days until the sum of daily rainfalls equals or exceeds 1.0 inch. If a sizable storm (rainfall greater than 0.3 inch) occurs within the four days prior to the test storm the earlier storm should also be modeled. The equivalent dry days should then be calculated using the actual surface residual plus the between-storm accumulation.

The data needed on the frequency of street cleaning, which is used to reduce the basic buildup of pollutants in the watershed plus the number of passes made by the street sweeper can be found from a public works department. The volume of liquid remaining in the catch basins may be found by analysis of the construction drawings. The quality of the remaining liquid can be estimated or measured. Presently a lack of data has precluded reasonable estimates of the quality of catch basin liquids and no parameters for catch basin quality are included in the program.

The data cards defining an individual subcatchment provide the model with the subcatchment, number, type of land use, the length of gutters in the subcatchment, and the number of catch basins in the subcatchment. Land use information may be obtained from a governmental planning department, direct observation, or by other means. The length of gutters within each subarea may be obtained by scaling them from a street map. The number of catch basins (gutter inlets) per acre may be estimated from visual observation or obtained from a public works department.

The final data cards for the Runoff Block are for the printing out of gutter and inlet hydrographs and pollutographs for the user. On the first card, the total number of gutters and inlets for which the results will be printed, and the time-step interval between the printing of the results are specified. The gutters and inlets for which the results are to be printed are then listed with a blank card terminating the model run.

TRANSPORT BLOCK

The Transport model is usually set up after the set up of the Runoff model. Therefore, decisions on the extent of the drainage system to be simulated by the Transport Block have previously been made. The data preparation is relatively straightforward with required information coming from field data and available drainage facilities maps and plans. The South Seattle Industrial Park calibration area example problem map, Figure III-2, shows a good example of a drainage system map with the necessary data on it for a simple pipe system.

In setting up the Transport model for a simulation run the data cards should be prepared according to the input data card formats presented in Chapter II of this report. The system control parameters are the first items to be considered and these include:

1. Simulation start time
2. Simulation end time
3. Time interval (or step) to be used for the numerical integration
4. Input hydrographs location information
5. Control information for the printing and plotting of results

These parameters control the solution and provide the information required for temporally correlating the runoff hydrographs computed in the watershed model for input to the Transport model. The user specifies the junctions and conduits for which he desires detailed results to be printed and plotted.

The spatial control parameters are contained within the physical system data which are delineated next. The conduits and junctions are represented by specifying the following data:

Conduits

1. Conduit number
2. Junctions which the conduit connects
3. Conduit type (circular, rectangular, etc.)
4. Cross-sectional area
5. Conduit height
6. Maximum width of conduit
7. Conduit length
8. Manning's "n" value
9. Distance of conduit invert above nodal elevation if different from zero
10. Head loss coefficients at junctions

Junctions

1. Junction number
2. Ground elevation at the node
3. Invert elevation at the node
4. Net value of constant inflow to the node, if any

The net inflow value is used for specifying the net rate of infiltration-exfiltration associated with the nodes as well as any other constant inflow or outflow that might be associated with the node.

These conduit and junction data specify the basic configuration of the system. Other system elements serve as transfer or diversion mechanisms for internodal transfers within the basic system defined by the conduit and node data. Data pertaining to these transfer elements are prepared next with the following information specified for each transfer element.

Orifices

1. Junction containing the orifice
2. Junction to which the orifice discharges
3. Cross-sectional area of the orifice
4. Discharge coefficient, C_0

Weirs

1. Junction containing the weir
2. Conduit into which the weir discharges*
3. Weir type (transverse, side flow, tide gate, no tide gate)
4. Vertical distance from node invert to weir crest
5. Vertical distance from the weir invert to the top of the pipe in which the weir is located
6. Weir length
7. Discharge coefficient, C_2
8. Discharge coefficient for surcharged condition, C'_w
(recommended value of C'_w is $C_w/8$)

Pumps

1. Node in which pumping station is located
2. Initial volume in the wet well
3. The three pumping rates that specify the rule curve for the pump station (see *Pumps* in the preceding section)
4. The three volumes associated with the three pumping rates

*If a conduit number of 0 is specified, this signals that the weir is an outfall weir.

Free Outfalls

1. Nodes which are free outfalls

Tide Gates on Free Outfalls

1. Free outfall nodes containing tide gates

Outfall Conditions

1. Water surface elevation/tidal conditions at outfall

Initialization of Flows and Heads

1. Initial values of flow and velocity for each conduit actually specified and internally generated
2. Initial value of head for each junction actually specified and internally generated

TRANSPORT QUALITY BLOCK

The Transport Quality model is used only if the Runoff model simulates runoff quality. The data required for the Transport Quality model simulation are system control parameters and the data cards should be prepared according to the input data card formats presented in Chapter II of this report. The system control parameters include:

1. Simulation start time
2. Simulation end time
3. Time interval (or step) to be used for the numerical integration

APPLICATION TO SOUTH SEATTLE INDUSTRIAL PARK

NORMAL RUNOFF CONDITIONS

Runoff Block

An example problem is given for the Runoff model. The discretization of the South Seattle Industrial Park calibration area is used as an example; the area map is shown in Figure III-2. The listing of the data cards for the example is given in Table III-2. The procedure for determining the data for the model representation of the drainage basin is as follows:

1. Define the drainage basin on a contour map of sufficient scale to readily show the drainage system for the example problem; in this case it is the area tributary to the sampling manhole which is designated as junction 1.
2. Determine the rainfall hyetograph for the simulation run for the basin--for the example problem, actual rainfall measurements from a nearby gage were used. The length of time of the hyetograph plus sixty minutes added at the end of the rainfall to allow for routing of the storm runoff was used for the length of the simulation.
3. Identify the drainage system to be used in the Runoff model--for the example problem, surface gutters flowing to drainage inlets were used.
4. Identify the inlets for the Runoff model drainage system--for the example problem, the drainage inlets were designated as inlets for the model to store hydrographs. These are numbered 1 through 7.

5. Identify the tributary area and drainage system to each inlet--for the example problem, eleven subcatchments and eleven gutters were used.
6. Determine values of parameters to represent drainage system gutters/pipes--for example problem, lengths, street section, slopes were measured and calculated. An "n" value of 0.015 was assumed for the gutters.
7. Determine values for parameters and coefficients to represent the subcatchments--for the example problem, area, width of subcatchment perpendicular to overland flow, percent imperviousness, average ground slope were determined for each subcatchment. Coefficients for resistance factors, retention storage, and infiltration were assumed to be those default values of the program.
8. Determine if quality constituents are to be modeled. If so, find the number of dry days prior to precipitation to be modeled, the street sweeping frequency, the number of passes per cleaning and the average catch basin volume. For the example problem actual rainfall records indicated that there were six dry days prior to the storm; from the public works department it was learned that the streets were swept once a week with one pass per cleaning; the average volume of a catch basin was assumed to be 25 cubic feet.
9. Within each subcatchment determine the length of gutters and the number of catch basins--for the example problem, the length of gutter was measured and there is one catch basin per subcatchment.
10. Identify those gutters for which printout of hydrographs and pollutographs are desired and the time interval for

the results to be printed--for the example problem, two gutters, 101 and 104, were selected for printout and an interval of 10 minutes (5 time steps) was selected.

11. Punch the cards and execute the program.

A reproduction of all computer output from the Runoff Block for the example problem is presented in Tables III-3 through III-9 and Figures III-4 and III-5.

Tables III-3 through III-6 show an echo of the input data and Tables III-7, III-8 and III-9 indicate the total mass balance and the time history of quality and quantity at gutters 101 and 104, respectively. Figure III-4 indicates the shape of the input hyetograph and Figure III-5 plots the shape of the surface flow hydrograph at junction 1. Figures III-6 to III-9 are examples of the hydrograph and pollutograph plots produced by the Runoff Block. Figure III-6 is a plot of the time history of flow at gutter 101 while Figures III-7 to III-9 are the time histories of three quality parameters at the same location.

MRE URBAN RUNOFF SIMULATION MODEL
SURFACE DRAINAGE QUANTITY AND QUALITY.....

TAPE ASSIGNMENTS

QUANTITY	QUALITY	QUALITY	QUALITY	PRINT	PLOT
INPUT	INPUT	OUTPUT	OUTPUT	FILE	FILE
8	9	14	15	11	12

SEATTLE URBAN RUNOFF AND BASIN DRAINAGE STUDY
MODIFIED EPA SURFACE RUNOFF MODEL

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA

SOUTH SEATTLE INDUSTRIAL PARK - RUNOFF WITH QUALITY MODEL - GUTTERS INCLUDED
EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL RUN NO. 1

BASIN NUMBER 1

NUMBER OF TIME STEPS 180

INTEGRATION TIME INTERVAL (MINUTES), 1.00

25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

FOR 30 RAINFALL STEPS, THE TIME INTERVAL IS 5.00 MINUTES

FOR RAINFALL NUMBER 1 RAINFALL HISTORY IS

.12	.00	.00	.00	.12	.00	.12	.00
.12	.00	.12	.00	.00	.00	.00	.00
.00	.00	.12	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00

TABLE III-3
PRINTED TAPE AND RAINFALL INPUT DATA

INPUT DATA FOR GUTTERS AND PIPES

INT NUM	GUT NUM	GUT CONN	WIDTH (FT)	LENGTH (FT)	SLOPE (FT/FT)	LEFT SIDE SLOPE RIGHT	MANNING N	DEPTH (FT)	V FULL (FPS)	Q FULL (CFS)
1	101	7	.00	640.	.00500	.1	.015	.4	2.4	6.
2	102	7	.00	630.	.00500	.1	.015	.4	2.4	6.
3	103	6	.00	230.	.00500	.1	.015	.4	2.4	6.
4	104	6	.00	190.	.00500	.1	.015	.4	2.4	6.
5	105	5	.00	290.	.00500	.1	.015	.4	2.4	6.
6	106	5	.00	290.	.00500	.1	.015	.4	2.4	6.
7	107	3	.00	290.	.00500	.1	.015	.4	2.4	6.
8	108	2	.00	230.	.00500	.1	.015	.4	2.4	6.
9	109	3	.00	290.	.00500	.1	.015	.4	2.4	6.
10	110	4	.00	240.	.00500	.1	.015	.4	2.4	6.
11	111	5	.00	160.	.00500	.1	.015	.4	2.4	6.

TOTAL NUMBER OF GUTTERS/PIPES, 11

ASTERISK (*) DENOTES CIRCULAR PIPE, DIAMETER=.WIDTH.

INT NUM	SUBAREA NUM	GUT/IN NUMBER	WIDTH (FT)	AREA (AC)	PERCENT IMPERV.	SLOPE (FT/FT)	RESISTANCE IMPERV.	FACTOR PERV.	SURFACE IMPERV.	STORAGE (IN)	INFILTRATION MINIMUM DECAY RATE	MAX. GAGE INF.	NO
1	1	101	630.	4.42	100.	.010	.013	.250	.062	.18	.00115	12.00	1
2	2	102	550.	4.67	100.	.010	.013	.250	.062	.18	.00115	12.00	1
3	3	103	300.	2.39	100.	.010	.013	.250	.062	.18	.00115	12.00	1
4	4	104	180.	2.10	100.	.010	.013	.250	.062	.18	.00115	12.00	1
5	5	105	300.	2.13	100.	.010	.013	.250	.062	.18	.00115	12.00	1
6	6	106	300.	1.95	80.	.010	.013	.250	.062	.18	.00115	12.00	1
7	7	107	310.	2.13	75.	.010	.013	.250	.062	.18	.00115	12.00	1
8	8	108	240.	1.68	75.	.010	.013	.250	.062	.18	.00115	12.00	1
9	9	109	220.	1.82	65.	.010	.013	.250	.062	.18	.00115	12.00	1
10	10	110	270.	2.09	65.	.010	.013	.250	.062	.18	.00115	12.00	1
11	11	111	250.	2.13	80.	.010	.013	.250	.062	.18	.00115	12.00	1

TOTAL NUMBER OF SUBCATCHMENTS, 11

TOTAL TRIBUTARY AREA (ACRES), 27.51

TABLE III-4
PRINTED CONDUIT AND WATERSHED INPUT DATA

ARRANGEMENT OF SUBCATCHMENTS AND GUTTERS/PIPES

GUTTER OR PIPE

TRIBUTARY GUTTER/PIPE

TRIBUTARY SUBAREA

101		1
102		2
103		3
104		4
105		5
106		6
107		7
108		8
109		9
110		10
111		11

TRIBUTARY SUBAREAS

TRIBUTARY GUTTERS AND/OR PIPES

INLET

7	101 102
6	103 104
5	105 106 111
3	107 109
2	108
4	110

HYDROGRAPHS WILL BE STORED FOR THE FOLLOWING 6 INLETS 4

TABLE III-5
GUTTER-WATERSHED CONNECTIONS

.....QUALITY SIMULATION INCLUDED IN THIS RUN.....

INPUT PARAMETERS AS FOLLOWS

NUMBER OF CONSTITUENTS 22
 NUMBER OF DRY DAYS 6.0
 STREET CLEANING FREQ 7.0 DAYS
 PASSES PER CLEANING 1
 STD CATCHBASIN VOLUME 25.00 FT3

WATERSHED QUALITY DEFINITIONS..... BASINS

SUBAREA	CLASS	GUTTER	BASINS
1	4	6.40	1.00
2	4	6.30	1.00
3	4	2.30	1.00
4	4	1.90	1.00
5	4	2.90	1.00
6	4	5.80	1.00
7	4	2.90	1.00
8	4	4.60	1.00
9	4	2.90	1.00
10	4	4.00	1.00
11	4	1.60	1.00

This information output only
 if surface quality is
 included in the simulation

TABLE III-6
 QUALITY SIMULATION PARAMETERS

TOTAL RAINFALL (CU FT)	.699027+04
TOTAL INFILTRATION (CU FT)	.797111+03
TOTAL GUTTER FLOW AT INLET (CU FT)	.165934+04
TOTAL SURFACE STORAGE AT END OF STORM (CU FT)	.434404+04
ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL,	2.71491

TABLE III-7
SIMULATION MASS BALANCE SUMMARY

SOUTH SEATTLE INDUSTRIAL PARK - RUNOFF WITH QUALITY MODEL - GUTTERS INCLUDED
 EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL RUN NO. 1

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 101

FLOW IN CFS AND QUALITY IN (MG/L) EXCEPT COLIFORMS IN (MPN/100ML)

TIME	FLOW	SET-9	SUS-9	TDS	BOD	COD	CHLOR	904	GREASE	TOT-COL	FEC-COL	NH3	ORG-NIT
8 40.00	.00	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
8 45.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
8 50.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
8 55.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 00.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 05.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 10.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 15.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 20.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 25.00	.04	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 30.00	.03	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 35.00	.04	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 40.00	.04	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 45.00	.06	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 50.00	.07	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 55.00	.07	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 00.00	.05	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 05.00	.04	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 10.00	.03	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 15.00	.03	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 20.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 25.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 30.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 35.00	.05	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 40.00	.05	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 45.00	.04	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 50.00	.04	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
10 55.00	.03	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 00.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 05.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 10.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 15.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 20.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 25.00	.02	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 30.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 35.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
11 40.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00

TABLE III-8
 LOCATION 101 FLOW AND QUALITY SUMMARY

SOUTH SEATTLE INDUSTRIAL PARK - RUNOFF WITH QUALITY MODEL - GUTTERS INCLUDED
 EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL RUN NO.1

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 101

FLOW IN CFS AND QUALITY IN (MG/L)

TIME	FLOW	NO3+NO2	T-HYD-P	ORTH-PO4	HG	CU	ZN	PR	CR	CD	AS
8 40.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8 45.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8 50.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8 55.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9 5.00	.01	.05	.02	.01	.00	.01	.03	.01	.00	.00	.00
9 10.00	.02	.27	.11	.03	.00	.03	.15	.08	.01	.00	.03
9 15.00	.02	.43	.17	.05	.00	.05	.25	.13	.01	.00	.04
9 20.00	.02	.58	.20	.05	.00	.06	.29	.15	.01	.00	.05
9 25.00	.04	.55	.22	.06	.00	.06	.32	.17	.01	.00	.06
9 30.00	.03	.59	.24	.06	.00	.07	.34	.18	.01	.01	.06
9 35.00	.05	.61	.25	.06	.00	.07	.35	.18	.01	.01	.06
9 40.00	.04	.62	.25	.07	.00	.07	.36	.19	.01	.01	.06
9 45.00	.06	.63	.26	.07	.00	.07	.36	.19	.01	.01	.06
9 50.00	.05	.63	.26	.07	.00	.07	.37	.19	.01	.01	.06
9 55.00	.07	.63	.26	.07	.00	.07	.37	.19	.01	.01	.06
10 .00	.05	.63	.26	.07	.00	.07	.37	.19	.01	.01	.06
10 5.00	.04	.63	.26	.07	.00	.07	.37	.19	.01	.01	.06
10 10.00	.03	.63	.26	.07	.00	.07	.36	.19	.01	.01	.06
10 15.00	.03	.63	.26	.07	.00	.07	.36	.19	.01	.01	.06
10 20.00	.02	.63	.26	.07	.00	.07	.36	.19	.01	.01	.06
10 25.00	.02	.63	.26	.07	.00	.07	.36	.19	.01	.01	.06
10 30.00	.01	.63	.26	.07	.00	.07	.36	.19	.01	.01	.06
10 35.00	.05	.63	.25	.07	.00	.07	.36	.19	.01	.01	.06
10 40.00	.04	.62	.25	.07	.00	.07	.36	.19	.01	.01	.06
10 45.00	.04	.62	.25	.07	.00	.07	.36	.19	.01	.01	.06
10 50.00	.04	.62	.25	.07	.00	.07	.36	.19	.01	.01	.06
10 55.00	.03	.62	.25	.07	.00	.07	.36	.19	.01	.01	.06
11 .00	.03	.62	.25	.07	.00	.07	.36	.19	.01	.01	.06
11 5.00	.02	.62	.25	.07	.00	.07	.35	.18	.01	.01	.06
11 10.00	.02	.61	.25	.07	.00	.07	.35	.18	.01	.01	.06
11 15.00	.02	.61	.25	.06	.00	.07	.35	.18	.01	.01	.06
11 20.00	.02	.61	.25	.06	.00	.07	.35	.18	.01	.01	.06
11 25.00	.02	.61	.25	.06	.00	.07	.35	.18	.01	.01	.06
11 30.00	.01	.61	.25	.06	.00	.07	.35	.18	.01	.01	.06
11 35.00	.01	.61	.25	.06	.00	.07	.35	.18	.01	.01	.06
11 40.00	.01	.61	.25	.06	.00	.07	.35	.18	.01	.01	.06

TABLE III-8
 (Continued)

SOUTH SEATTLE INDUSTRIAL PARK - RUNOFF WITH QUALITY MODEL - GUTTERS INCLUDED
 EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL RUN NO.1

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 104

FLOW IN CFS AND QUALITY IN (MG/L) EXCEPT COLIFORMS IN (MPN/100ML)

TIME	FLOW	SET-9	SUS-9	TDS	BOD	COD	CHLOR	S04	GREASE	TOT-COL	FEC-COL	NM3	ORG-NIT
8 40.00	.00	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
8 45.00	.00	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
8 50.00	.00	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
8 55.00	.00	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 00.00	.00	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 05.00	.00	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 10.00	.01	.0	.0	.0	.00	.0	.00	.00	.00	.00	.00	.00	.00
9 15.00	.01	19.8	28.0	64.5	1.57	26.9	4.25	6.25	3.97	6.74+03	8.64+02	.00	.00
9 20.00	.01	31.5	44.6	102.9	2.51	42.9	6.78	9.97	6.33	1.07+04	1.38+03	.07	.32
9 25.00	.01	37.0	53.5	123.5	3.01	51.6	8.14	11.97	7.60	1.29+04	1.65+03	.11	.50
9 30.00	.01	40.5	57.3	132.4	3.22	55.2	8.72	12.82	8.15	1.38+04	1.77+03	.13	.61
9 35.00	.02	41.5	58.7	135.6	3.30	56.6	8.94	13.14	8.35	1.41+04	1.82+03	.14	.65
9 40.00	.02	41.8	59.1	136.6	3.33	57.0	9.00	13.23	8.41	1.43+04	1.83+03	.14	.67
9 45.00	.02	41.8	59.2	136.7	3.33	57.0	9.01	13.24	8.41	1.43+04	1.83+03	.14	.67
9 50.00	.02	41.7	59.0	136.3	3.32	56.9	8.99	13.21	8.39	1.42+04	1.83+03	.14	.67
9 55.00	.03	41.6	58.8	135.8	3.31	56.7	8.95	13.16	8.36	1.42+04	1.82+03	.14	.67
10 00.00	.02	41.4	58.6	135.3	3.29	56.5	8.92	13.10	8.33	1.41+04	1.81+03	.14	.66
10 05.00	.02	41.2	58.3	134.7	3.28	56.2	8.88	13.05	8.30	1.41+04	1.80+03	.14	.66
10 10.00	.02	41.1	58.1	134.3	3.27	56.0	8.85	13.01	8.27	1.40+04	1.80+03	.14	.66
10 15.00	.01	41.0	58.0	133.9	3.26	55.9	8.82	12.97	8.24	1.40+04	1.79+03	.14	.66
10 20.00	.01	40.9	57.8	133.5	3.25	55.7	8.80	12.93	8.22	1.39+04	1.79+03	.14	.65
10 25.00	.01	40.8	57.7	133.2	3.24	55.6	8.78	12.90	8.20	1.39+04	1.78+03	.14	.65
10 30.00	.01	40.7	57.6	132.9	3.24	55.5	8.76	12.88	8.19	1.39+04	1.78+03	.14	.65
10 35.00	.02	40.6	57.4	132.6	3.23	55.3	8.74	12.85	8.16	1.38+04	1.78+03	.14	.65
10 40.00	.02	40.4	57.2	132.1	3.22	55.2	8.71	12.80	8.13	1.38+04	1.77+03	.14	.65
10 45.00	.02	40.3	57.0	131.7	3.21	55.0	8.68	12.76	8.11	1.37+04	1.76+03	.14	.65
10 50.00	.02	40.2	56.9	131.3	3.20	54.8	8.65	12.72	8.08	1.37+04	1.76+03	.14	.64
10 55.00	.01	40.1	56.7	130.9	3.19	54.6	8.63	12.68	8.06	1.37+04	1.75+03	.14	.64
11 00.00	.01	40.0	56.5	130.6	3.18	54.5	8.61	12.65	8.04	1.36+04	1.75+03	.14	.64
11 05.00	.01	39.9	56.4	130.2	3.17	54.4	8.58	12.62	8.02	1.36+04	1.74+03	.14	.64
11 10.00	.01	39.8	56.3	130.0	3.16	54.2	8.57	12.59	8.00	1.36+04	1.74+03	.14	.64
11 15.00	.01	39.7	56.2	129.7	3.16	54.1	8.55	12.56	7.98	1.35+04	1.74+03	.14	.64
11 20.00	.01	39.6	56.1	129.5	3.15	54.0	8.53	12.54	7.97	1.35+04	1.73+03	.14	.63
11 25.00	.01	39.6	56.0	129.2	3.15	53.9	8.52	12.52	7.96	1.35+04	1.73+03	.14	.63
11 30.00	.01	39.5	55.9	129.0	3.14	53.9	8.50	12.50	7.94	1.35+04	1.73+03	.14	.63
11 35.00	.01	39.4	55.8	128.8	3.14	53.8	8.49	12.48	7.93	1.34+04	1.73+03	.14	.63
11 40.00	.01	39.4	55.7	128.7	3.13	53.7	8.48	12.47	7.92	1.34+04	1.72+03	.14	.63

TABLE III-9

LOCATION 104 FLOW AND QUALITY SUMMARY

AD-A042 197

KCM-WRE/YTO SEATTLE WASH
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74

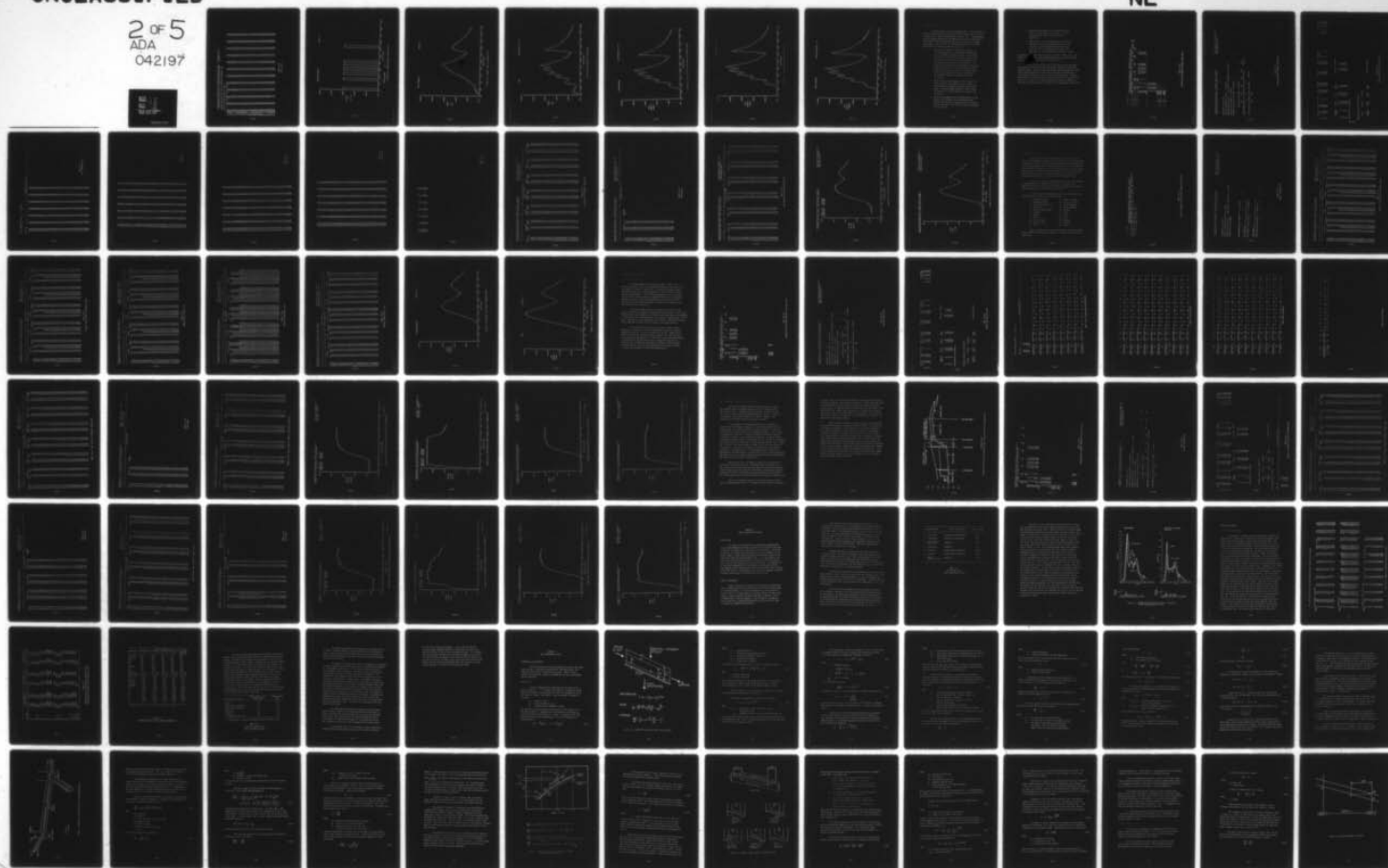
F/G 8/8

DACW67-73-C-0022

NL

UNCLASSIFIED

2 OF 5
ADA
042197



SOUTH SEATTLE INDUSTRIAL PARK - RUNOFF WITH QUALITY MODEL - GUTTERS INCLUDED
 EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL
 RUN NO. 1

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 104

FLOW IN CFS AND QUALITY IN (MG/L)

TIME	FLOW	NO3+NO2	T-HYD-P	ORTH-P04	HG	CU	ZN	PB	CR	CD	AS
8 40.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8 45.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8 50.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8 55.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9 5.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9 10.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9 15.00	.01	.19	.08	.02	.00	.02	.00	.06	.00	.00	.02
9 20.00	.01	.30	.12	.03	.00	.03	.18	.09	.01	.00	.03
9 25.00	.01	.37	.15	.04	.00	.04	.21	.11	.01	.00	.04
9 30.00	.01	.39	.16	.04	.00	.04	.23	.12	.01	.00	.04
9 35.00	.02	.40	.16	.04	.00	.04	.23	.12	.01	.00	.04
9 40.00	.02	.40	.16	.04	.00	.05	.23	.12	.01	.00	.04
9 45.00	.02	.40	.16	.04	.00	.05	.23	.12	.01	.00	.04
9 50.00	.02	.40	.16	.04	.00	.05	.23	.12	.01	.00	.04
9 55.00	.03	.40	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 5.00	.02	.40	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 10.00	.02	.40	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 15.00	.02	.40	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 20.00	.01	.40	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 25.00	.01	.39	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 30.00	.01	.39	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 35.00	.02	.39	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 40.00	.02	.39	.16	.04	.00	.04	.23	.12	.01	.00	.04
10 45.00	.02	.39	.16	.04	.00	.04	.22	.12	.01	.00	.04
10 50.00	.02	.39	.16	.04	.00	.04	.22	.12	.01	.00	.04
10 55.00	.01	.39	.16	.04	.00	.04	.22	.12	.01	.00	.04
11 5.00	.01	.39	.16	.04	.00	.04	.22	.12	.01	.00	.04
11 10.00	.01	.39	.16	.04	.00	.04	.22	.12	.01	.00	.04
11 15.00	.01	.38	.16	.04	.00	.04	.22	.12	.01	.00	.04
11 20.00	.01	.38	.16	.04	.00	.04	.22	.12	.01	.00	.04
11 25.00	.01	.38	.16	.04	.00	.04	.22	.11	.01	.00	.04
11 30.00	.01	.38	.15	.04	.00	.04	.22	.11	.01	.00	.04
11 35.00	.01	.38	.15	.04	.00	.04	.22	.11	.01	.00	.04
11 40.00	.01	.38	.15	.04	.00	.04	.22	.11	.01	.00	.04

TABLE III-9
 (Continued)

RAINFALL HYETOGRAPH

BASIN NO 1

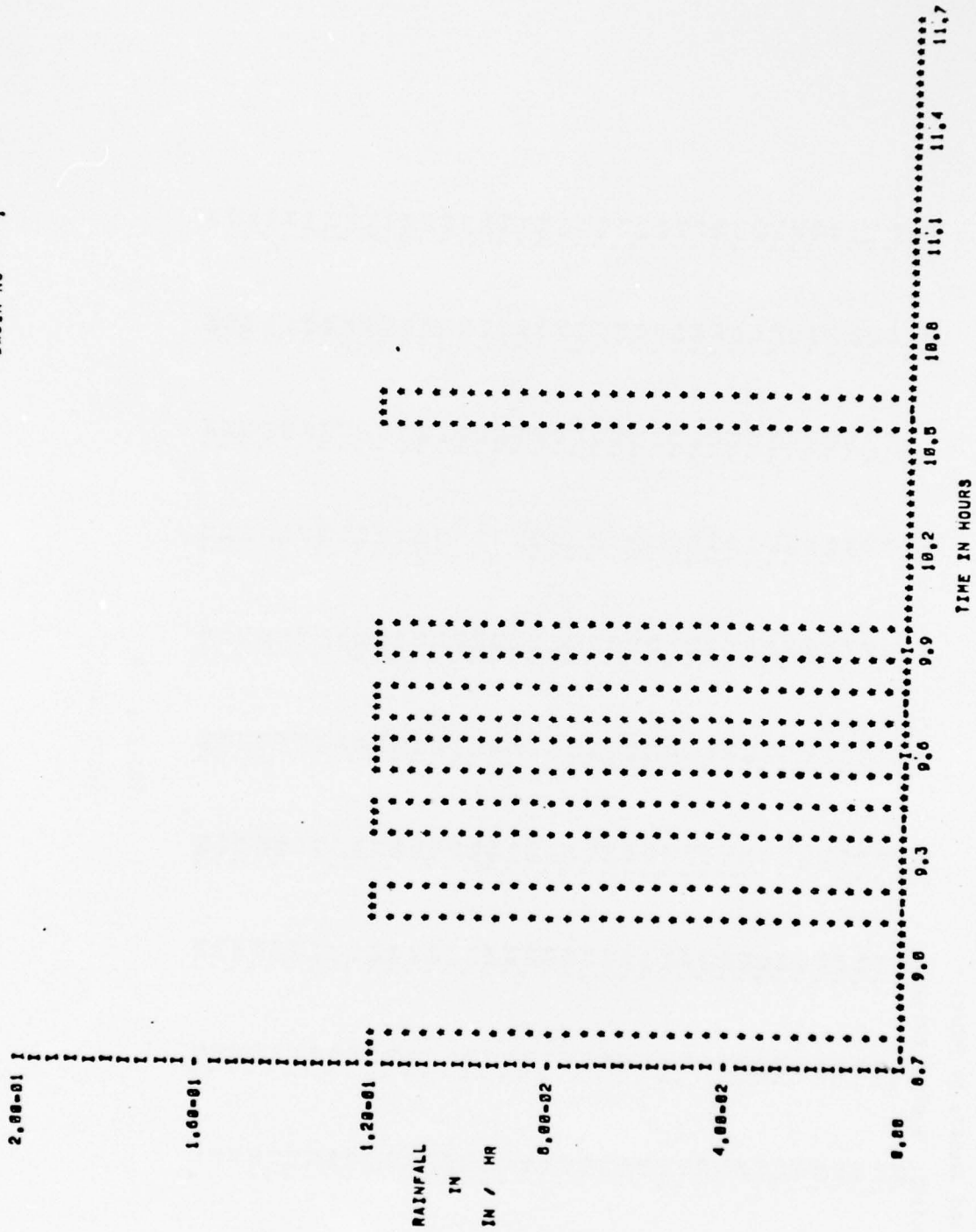


FIGURE III-4 EXAMPLE PROBLEM, HYETOGRAPH PLOT

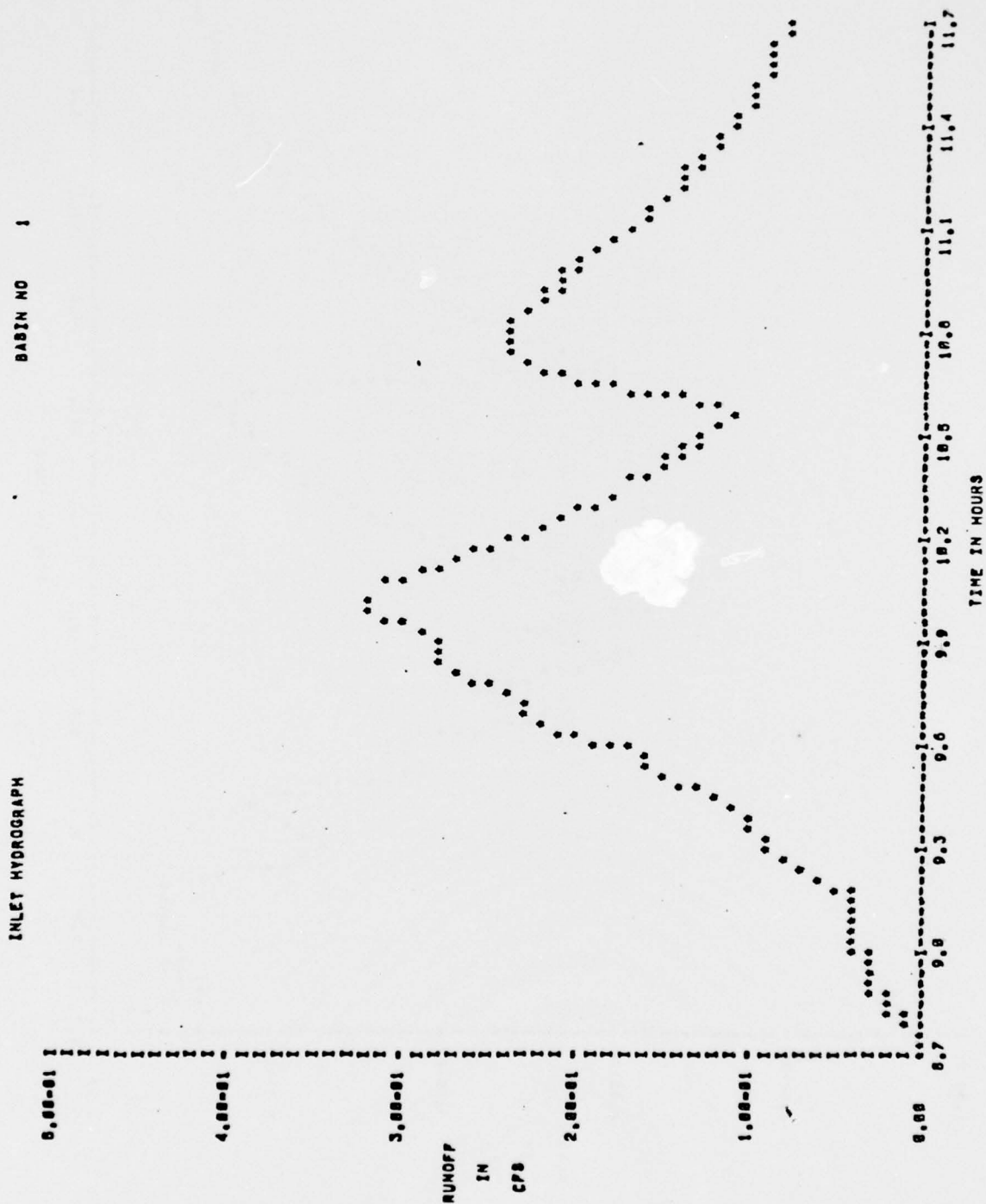


FIGURE III-5 EXAMPLE PROBLEM, HYDROGRAPH PLOT

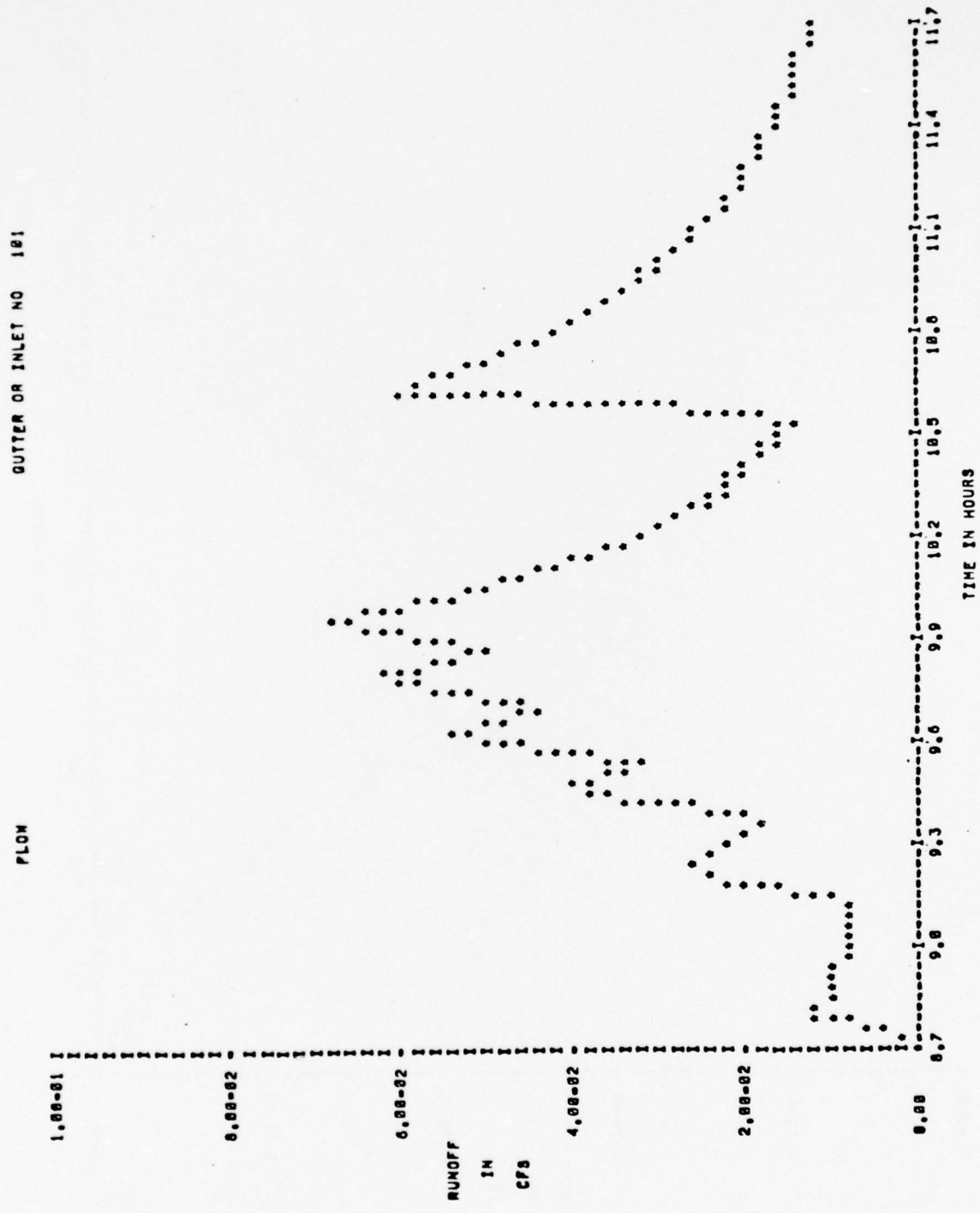


FIGURE III-6 TIME HISTORY OF GUTTER FLOW

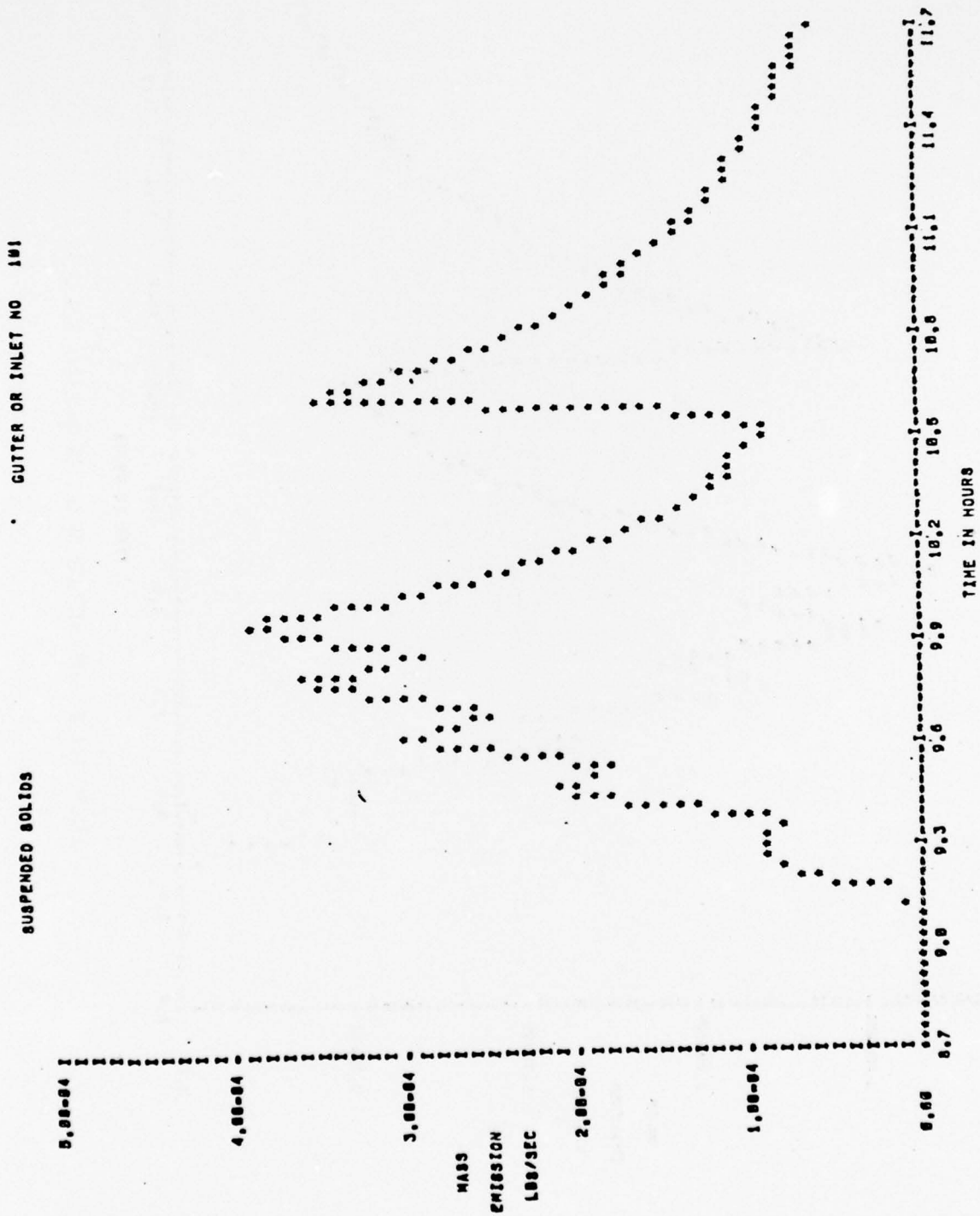


FIGURE III-7 TIME HISTORY OF GUTTER QUALITY--SUSPENDED SOLIDS

GUTTER OR INLET NO. 101

3.0 D.

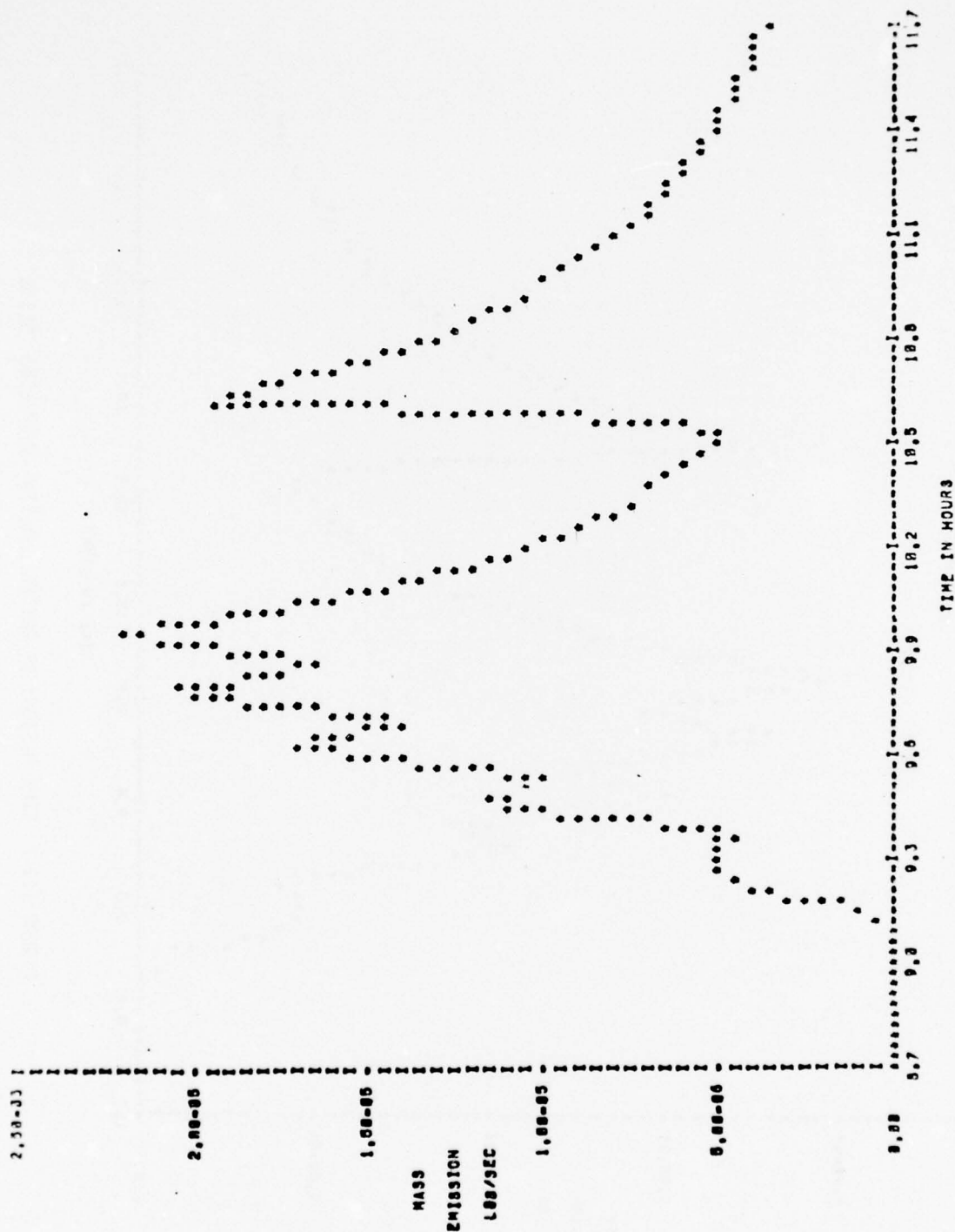


FIGURE III-8 TIME HISTORY OF GUTTER QUALITY--B.O.D.

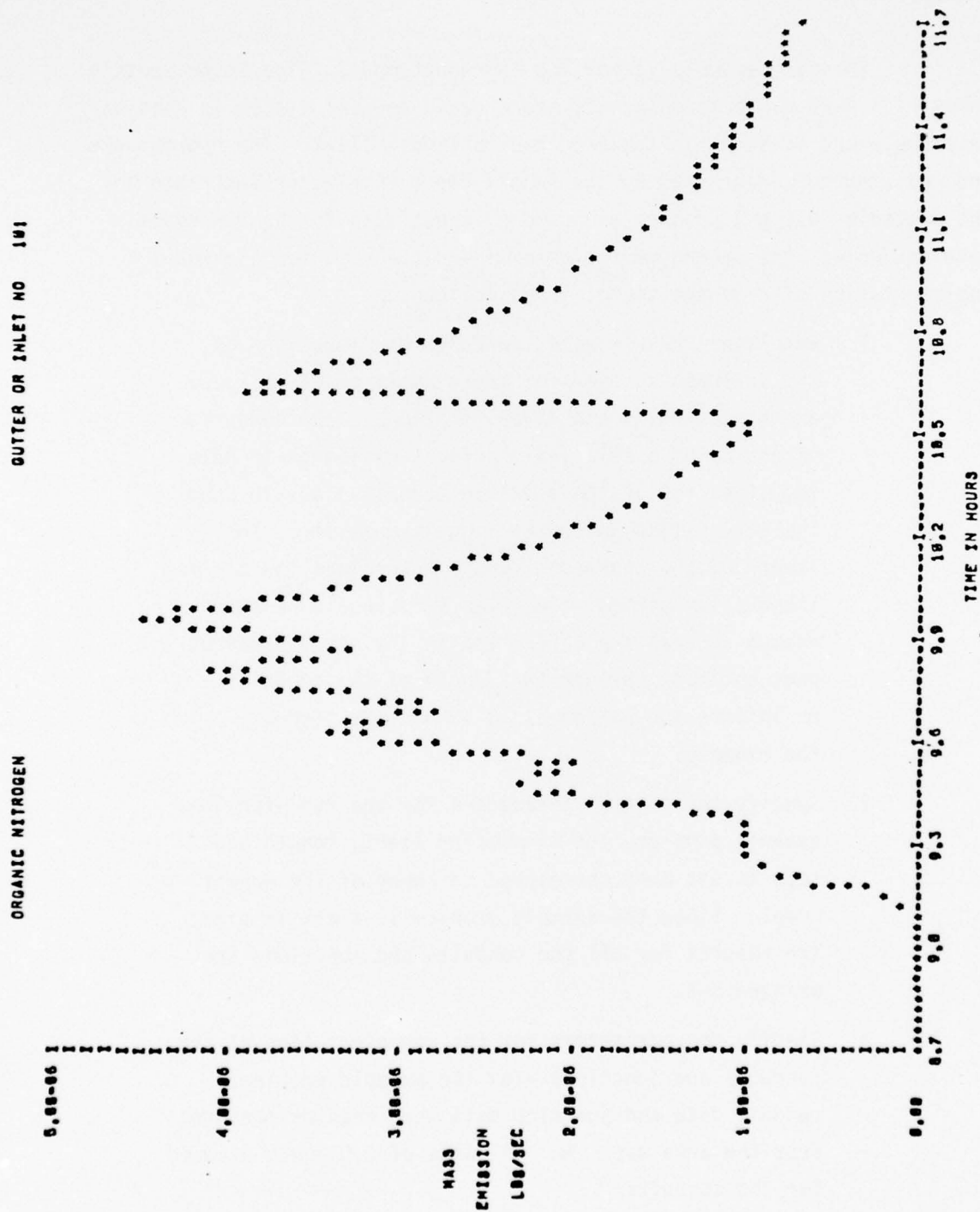


FIGURE III-9 TIME HISTORY OF GUTTER QUALITY

Transport Block

The next example is for the Transport model. The South Seattle Industrial Park calibration area's storm drain conduit system is used as an example and is shown in the area map in Figure III-2. The hydrographs and pollutographs generated by the Runoff Block simulation described in the preceding example problem are used as input data to the Transport model example. The procedure for determining the data for the model representation of drainage system is as follows:

1. Determine the elements, conduits and junctions of the drainage system--for the example problem, there are six conduits and seven junctions. The conduits should be of a relatively consistent length to help the stability of the solution technique and to keep the integration period as long as possible. The length of the shortest conduit determines the maximum integration period. The time step should be short enough so that the water flow in the conduit cannot pass entirely through the length of the conduit. An integration period of 10 seconds is used in the example.
2. Specify the control parameters for the run--for the example problem, the simulation start, length and tape inputs must correspond to those of the Runoff model. Since the example problem is small in size, the results for all the conduits and junctions are printed out.
3. Specify the parameters for the representation of the conduits and junctions--for the example problem, conduit data and junction data were read or measured from the area map. An "n" value of 0.015 was assumed for the conduits.

4. Specify the parameters for the representation of orifices, weirs, pumps, and outfalls. For the example problem, only one free outfall was specified.
5. Specify the initial dry weather flows and heads for the actual and internally generated conduits and junctions. For the example problem three blank cards for the initial heads are included in the data deck (i.e., initialize flows and heads to zero).

A listing of the actual input data cards is given in Table III-10. The results of the Transport model example problem are presented in Tables III-11 through III-15 and Figures III-10 and III-11.

Tables III-11 and III-12 are an echo check of the card input data, while III-13 shows the input hydrographs produced as output from the Runoff Block. Table III-14 gives the position of the hydraulic grade line at selected junctions in the system and Table III-15 provides a time history of flow and velocity in various system conduits. Typical printer plots of relevant system information are shown in Figures III-10 and III-11. Figure III-10 indicates the water surface of junction 2, while the time history of flow in conduit 201 is displayed in Figure III-11.

	SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1												
	EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL												
	1080	10	840	7	6	2	2	1	30	0	15	GUTQAL	12
1													
2													
3													
4													
		1		2	6	2	3	4	5	6	7		
	201	202	203	204	205	206	207	208	209	210	211	212	213

SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1													
EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL													
	1080	10	840	7	6	2	2	1	30	0	15	GUTQAL	12
1													
2													
3													
4													
		1		2	6	2	3	4	5	6	7		
	201	202	203	204	205	206	207	208	209	210	211	212	213

5	2	7	0.015
6	201	2.25	.015
7	202	2.0	.015
	203	2.0	.015
	204	1.75	.015
	205	1.5	.015
	206	1.0	.015
	00000		

8	1	4.0	8.1
	2	4.0	1.1
	3	4.0	1.9
	4	5.0	2.5
	5	5.0	3.4
	6	6.0	4.2
	7	7.0	4.6
	9999		
9	9999		
10	9999		
11	9999		
	1		
12	9999		
13	9999		
14	1		

TABLE III-10

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE MODEL

SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1
EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL

INTEGRATION CYCLES 1000

LENGTH OF INTEGRATION STEP IS 10. SECONDS

PRINTING STARTS IN CYCLE 1 AND PRINTS AT INTERVALS OF 30 CYCLES

INITIAL TIME 8 HOURS, 40 MINUTES

PRINTED OUTPUT AT THE FOLLOWING 7 JUNCTIONS

1	2	3	4	5	6	7
---	---	---	---	---	---	---

AND FOR THE FOLLOWING 6 CONDUITS

201	202	203	204	205	206
-----	-----	-----	-----	-----	-----

WATER SURFACE ELEVATIONS WILL BE PLOTTED FOR THE FOLLOWING 2 JUNCTIONS

2	7
---	---

FLOW RATE WILL BE PLOTTED FOR THE FOLLOWING 2 CONDUITS

201	204
-----	-----

TABLE III-11
PRINTED EXAMPLE PROBLEM CONTROL DATA

CONDUIT NUMBER	LENGTH (FT)	CLASS	AREA (SQ FT)	MANHATTING (C.F.F.)	MAX WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT ENDS	TRAPEZOID SIDE SLOPE
1	201	1	3.98	.015	2.25	2.25	2	.0
2	202	1	3.14	.015	2.00	2.00	3	.0
3	203	1	3.14	.015	2.00	2.00	4	.0
4	204	1	2.41	.015	1.75	1.75	5	.0
5	205	1	1.77	.015	1.50	1.50	6	.0
6	206	1	1.77	.015	1.50	1.50	7	.0

JUNCTION NUMBER	GROUND ELEV.	INVERT ELEV.	QINST (CFS)	CONNECTING CONDUITS
1	4.00	.10	.00	201
2	4.00	1.10	.00	201 202
3	4.50	1.90	.00	202 203
4	5.00	2.50	.00	203 204
5	5.50	3.40	.00	204 205
6	6.00	4.20	.00	205 206
7	7.00	4.60	.00	206

FREE OUTFLOW AT JUNCTIONS.

1

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION	QINST (CFS)
7	1	0	

TABLE III-12
PRINTED CONDUIT AND JUNCTION DATA

INPUT HYDROGRAPHS (TAPE) AT 6 JUNCTIONS

TIME, HRS	7	6	5	3	2	4
8.67	.00	.00	.00	.00	.00	.00
8.68	.00	.00	.00	.00	.00	.00
8.70	.00	.00	.00	.00	.00	.00
8.72	.00	.00	.00	.00	.00	.00
8.73	.00	.00	.00	.00	.00	.00
8.75	.00	.00	.00	.00	.00	.00
8.77	.00	.00	.00	.00	.00	.00
8.78	.00	.00	.00	.00	.00	.00
8.80	.00	.00	.00	.00	.00	.00
8.82	.00	.00	.00	.00	.00	.00
8.83	.00	.00	.00	.00	.00	.00
8.85	.00	.00	.00	.00	.00	.00
8.87	.00	.00	.00	.00	.00	.00
8.88	.00	.00	.00	.00	.00	.00
8.90	.00	.00	.00	.00	.00	.00
8.92	.00	.00	.00	.00	.00	.00
8.93	.00	.00	.00	.00	.00	.00
8.95	.00	.00	.00	.00	.00	.00
8.97	.00	.00	.00	.00	.00	.00
8.98	.00	.00	.00	.00	.00	.00
9.00	.00	.00	.00	.00	.00	.00
9.02	.00	.00	.00	.00	.00	.00
9.03	.00	.00	.00	.00	.00	.00
9.05	.00	.00	.00	.00	.00	.00
9.07	.00	.00	.00	.00	.00	.00
9.08	.00	.00	.00	.00	.00	.00
9.10	.00	.00	.00	.00	.00	.00
9.12	.00	.00	.00	.00	.00	.00
9.13	.00	.00	.00	.00	.00	.00
9.15	.00	.00	.00	.00	.00	.00
9.17	.00	.00	.00	.00	.00	.00
9.18	.00	.00	.00	.00	.00	.00
9.20	.00	.00	.00	.00	.00	.00
9.22	.00	.00	.00	.00	.00	.00
9.23	.00	.00	.00	.00	.00	.00
9.25	.00	.00	.00	.00	.00	.00
9.27	.00	.00	.00	.00	.00	.00
9.28	.00	.00	.00	.00	.00	.00
9.30	.00	.00	.00	.00	.00	.00
9.32	.00	.00	.00	.00	.00	.00
9.33	.00	.00	.00	.00	.00	.00
9.35	.00	.00	.00	.00	.00	.00
9.37	.00	.00	.00	.00	.00	.00
9.38	.00	.00	.00	.00	.00	.00
9.40	.00	.00	.00	.00	.00	.00
9.42	.00	.00	.00	.00	.00	.00
9.43	.00	.00	.00	.00	.00	.00
9.45	.00	.00	.00	.00	.00	.00
9.47	.00	.00	.00	.00	.00	.00
9.48	.00	.00	.00	.00	.00	.00
9.50	.00	.00	.00	.00	.00	.00
9.52	.00	.00	.00	.00	.00	.00
9.53	.00	.00	.00	.00	.00	.00

TABLE III-13
INPUT HYDROGRAPH DATA

9.55	.05	.03	.04	.02	.01	.01
9.57	.06	.03	.05	.02	.01	.01
9.58	.06	.04	.05	.03	.01	.01
9.60	.06	.04	.05	.03	.01	.01
9.62	.07	.04	.05	.03	.01	.01
9.63	.07	.04	.06	.03	.01	.02
9.65	.07	.04	.06	.03	.01	.02
9.67	.07	.04	.06	.03	.01	.02
9.68	.07	.04	.06	.03	.01	.02
9.70	.07	.04	.06	.03	.01	.02
9.72	.08	.04	.06	.03	.01	.02
9.73	.08	.04	.06	.03	.01	.02
9.75	.08	.05	.06	.03	.02	.02
9.77	.09	.05	.07	.03	.02	.02
9.78	.09	.05	.07	.04	.02	.02
9.80	.09	.05	.07	.04	.02	.02
9.82	.09	.05	.07	.04	.02	.02
9.83	.09	.05	.07	.04	.02	.02
9.85	.09	.05	.07	.04	.02	.02
9.87	.10	.05	.07	.04	.02	.02
9.88	.10	.05	.07	.04	.02	.02
9.90	.10	.05	.07	.04	.02	.02
9.92	.10	.05	.07	.04	.02	.02
9.93	.11	.06	.07	.04	.02	.02
9.95	.11	.06	.08	.04	.02	.02
9.97	.11	.06	.08	.04	.02	.02
9.98	.11	.05	.08	.04	.02	.02
10.00	.11	.06	.07	.04	.02	.02
10.02	.11	.06	.07	.04	.02	.02
10.03	.11	.05	.07	.04	.02	.02
10.05	.11	.05	.07	.04	.02	.02
10.07	.11	.05	.07	.03	.02	.02
10.08	.11	.05	.06	.03	.02	.02
10.10	.13	.05	.06	.03	.01	.02
10.12	.10	.05	.06	.03	.01	.01
10.13	.10	.04	.06	.03	.01	.01
10.15	.10	.04	.06	.03	.01	.01
10.17	.09	.04	.05	.03	.01	.01
10.18	.09	.04	.05	.03	.01	.01
10.20	.09	.04	.05	.02	.01	.01
10.22	.09	.04	.05	.02	.01	.01
10.23	.09	.04	.04	.02	.01	.01
10.25	.08	.03	.04	.02	.01	.01
10.27	.08	.03	.04	.02	.01	.01
10.28	.08	.03	.04	.02	.01	.01
10.30	.08	.03	.04	.02	.01	.01
10.32	.07	.03	.03	.02	.01	.01
10.33	.07	.03	.03	.02	.01	.01
10.35	.07	.03	.03	.02	.01	.01
10.37	.07	.03	.03	.02	.01	.01
10.39	.07	.03	.03	.02	.01	.01
10.40	.06	.03	.03	.02	.01	.01
10.42	.06	.02	.03	.01	.01	.01
10.43	.06	.02	.03	.01	.01	.01
10.45	.06	.02	.03	.01	.01	.01
10.47	.06	.02	.02	.01	.01	.01
10.49	.05	.02	.02	.01	.01	.01
10.50	.05	.02	.02	.01	.01	.01
10.52	.05	.02	.02	.01	.00	.00
10.53	.05	.02	.02	.01	.00	.01

TABLE III-13
(Continued)

10.53	.05	.02	.02	.01	.01	.01
10.57	.05	.02	.03	.01	.01	.01
10.59	.06	.03	.03	.01	.01	.01
10.63	.06	.03	.04	.01	.01	.01
10.64	.06	.04	.04	.02	.01	.01
10.62	.06	.04	.04	.02	.01	.01
10.63	.07	.04	.05	.02	.01	.01
10.65	.07	.04	.05	.03	.01	.01
10.67	.07	.04	.06	.03	.01	.01
10.67	.07	.04	.06	.03	.01	.01
10.68	.08	.04	.06	.03	.01	.02
10.70	.08	.04	.06	.03	.01	.02
10.72	.08	.04	.06	.03	.01	.02
10.73	.08	.04	.06	.03	.01	.02
10.75	.08	.04	.06	.03	.01	.02
10.77	.08	.04	.06	.03	.01	.02
10.78	.08	.04	.06	.03	.01	.02
10.83	.08	.04	.06	.03	.01	.02
10.82	.08	.04	.05	.03	.01	.01
10.93	.08	.04	.05	.03	.01	.01
10.95	.08	.04	.05	.03	.01	.01
10.95	.08	.04	.05	.03	.01	.01
10.97	.07	.03	.04	.02	.01	.01
10.98	.07	.03	.04	.02	.01	.01
11.02	.07	.03	.04	.02	.01	.01
11.02	.07	.03	.04	.02	.01	.01
11.02	.07	.03	.04	.02	.01	.01
11.03	.07	.03	.04	.02	.01	.01
11.05	.07	.03	.04	.02	.01	.01
11.07	.07	.03	.04	.02	.01	.01
11.08	.07	.03	.04	.02	.01	.01
11.10	.06	.03	.03	.02	.01	.01
11.12	.06	.03	.03	.02	.01	.01
11.13	.06	.03	.03	.02	.01	.01
11.14	.06	.03	.03	.02	.01	.01
11.17	.06	.03	.03	.02	.01	.01
11.18	.06	.02	.03	.02	.01	.01
11.20	.06	.02	.03	.02	.01	.01
11.22	.06	.02	.03	.02	.01	.01
11.23	.06	.02	.03	.02	.01	.01
11.25	.05	.02	.03	.02	.01	.01
11.27	.05	.02	.03	.02	.01	.01
11.28	.05	.02	.03	.02	.01	.01
11.30	.05	.02	.03	.02	.01	.01
11.32	.05	.02	.03	.02	.01	.01
11.33	.05	.02	.02	.02	.01	.01
11.35	.05	.02	.02	.02	.01	.01
11.37	.05	.02	.02	.02	.01	.01
11.38	.05	.02	.02	.02	.01	.01
11.42	.05	.02	.02	.02	.01	.01
11.42	.04	.02	.02	.02	.01	.01
11.43	.04	.02	.02	.02	.01	.01
11.45	.04	.02	.02	.02	.01	.01
11.47	.04	.02	.02	.02	.01	.01
11.48	.04	.02	.02	.02	.01	.01
11.50	.04	.02	.02	.02	.01	.01
11.52	.04	.02	.02	.02	.01	.01
11.53	.04	.02	.02	.02	.01	.01

TABLE III-13
(Continued)

10.55	.05	.02	.01	.01	.01
10.57	.05	.03	.01	.01	.01
10.59	.06	.03	.02	.01	.01
10.61	.06	.04	.02	.01	.01
10.63	.07	.04	.02	.01	.01
10.65	.07	.04	.03	.01	.01
10.67	.07	.04	.03	.01	.01
10.69	.08	.04	.03	.01	.02
10.70	.08	.04	.03	.01	.02
10.72	.08	.04	.03	.01	.02
10.73	.08	.04	.03	.01	.02
10.75	.08	.04	.03	.01	.02
10.77	.08	.04	.03	.01	.02
10.78	.08	.04	.03	.01	.02
10.80	.08	.04	.03	.01	.02
10.82	.08	.04	.03	.01	.01
10.93	.08	.04	.03	.01	.01
10.95	.08	.04	.03	.01	.01
10.97	.08	.04	.03	.01	.01
10.98	.07	.03	.02	.01	.01
11.00	.07	.03	.02	.01	.01
11.02	.07	.03	.02	.01	.01
11.03	.07	.03	.02	.01	.01
11.04	.07	.03	.02	.01	.01
11.07	.07	.03	.02	.01	.01
11.08	.07	.03	.02	.01	.01
11.10	.06	.03	.02	.01	.01
11.12	.06	.03	.02	.01	.01
11.13	.06	.03	.02	.01	.01
11.15	.06	.03	.02	.01	.01
11.17	.06	.03	.02	.01	.01
11.18	.06	.03	.02	.01	.01
11.20	.06	.03	.02	.01	.01
11.22	.06	.03	.02	.01	.01
11.23	.06	.03	.02	.01	.01
11.25	.05	.03	.02	.01	.01
11.27	.05	.03	.02	.01	.01
11.28	.05	.03	.02	.01	.01
11.30	.05	.03	.02	.01	.01
11.32	.05	.03	.02	.01	.01
11.33	.05	.03	.02	.01	.01
11.35	.05	.03	.02	.01	.01
11.37	.05	.03	.02	.01	.01
11.38	.05	.03	.02	.01	.01
11.40	.05	.03	.02	.01	.01
11.42	.04	.02	.02	.01	.01
11.43	.04	.02	.02	.01	.01
11.45	.04	.02	.02	.01	.01
11.47	.04	.02	.02	.01	.01
11.48	.04	.02	.02	.01	.01
11.50	.04	.02	.02	.01	.01
11.52	.04	.02	.02	.01	.01
11.53	.04	.02	.02	.01	.01

TABLE III-13
(Continued)

11.55	.04	.02	.01	.04	.00
11.57	.04	.02	.01	.03	.00
11.58	.04	.02	.01	.03	.00
11.59	.04	.02	.01	.03	.00
11.62	.04	.02	.01	.03	.00
11.63	.03	.01	.01	.03	.00
11.65	.03	.01	.01	.03	.00
11.67	.03	.01	.01	.03	.00

TABLE III-13
(Continued)

SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1
EXAMPLE PROBLEM USING STORY OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE MODEL

TIME HISTORY OF H. C. L. (VALUES IN FEET)									
TIME HR. MIN	JUNCTION GRND ELEV	JUNCTION 4.00 DEPTH	JUNCTION GRND ELEV	JUNCTION 4.50 DEPTH	JUNCTION 5.00 DEPTH	JUNCTION 5.50 DEPTH	JUNCTION GRND ELEV	JUNCTION 6.00 DEPTH	JUNCTION GRND ELEV
8:40	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
8:45	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
8:50	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
8:55	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:00	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:05	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:10	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:15	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:20	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:25	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:30	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:35	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:40	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:45	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:50	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
9:55	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:00	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:05	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:10	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:15	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:20	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:25	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:30	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:35	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:40	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:45	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:50	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
10:55	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:00	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:05	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:10	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:15	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:20	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:25	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:30	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:35	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20
11:40	1.0	.00	1.90	.00	2.50	.00	3.40	.00	4.20

TABLE III-14
TIME HISTORY OF HYDRAULIC GRADE LINE

SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1
 EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

***** TIME HISTORY OF H. G. L. *****
 (VALUES IN FEET)

TIME	JUNCTION GRND	JUNCTION GRND
8.40	4.60	.00
8.45	4.60	.00
8.50	4.61	.01
8.55	4.63	.03
9.00	4.64	.04
9.05	4.65	.05
9.10	4.66	.06
9.15	4.68	.08
9.20	4.69	.09
9.25	4.69	.09
9.30	4.71	.11
9.35	4.72	.12
9.40	4.74	.14
9.45	4.75	.15
9.50	4.76	.16
9.55	4.76	.16
10.00	4.77	.17
10.05	4.77	.17
10.10	4.76	.16
10.15	4.75	.15
10.20	4.74	.14
10.25	4.73	.13
10.30	4.72	.12
10.35	4.72	.12
10.40	4.74	.14
10.45	4.75	.15
10.50	4.75	.15
10.55	4.75	.15
11.00	4.74	.14
11.05	4.74	.14
11.10	4.73	.13
11.15	4.72	.12
11.20	4.72	.12
11.25	4.71	.11
11.30	4.71	.11
11.35	4.70	.10
11.40	4.70	.10

TABLE III-14
 (Continued)

SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1
 EXAMPLE PROBLEM USING STORM OF MARCH 10, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

***** TIME HISTORY OF FLOW AND VELOCITY *****												
TIME HR	CONDUIT FLOW	201 VEL	CONDUIT FLOW	202 VEL	CONDUIT FLOW	203 VEL	CONDUIT FLOW	204 VEL	CONDUIT FLOW	205 VEL	CONDUIT FLOW	206 VEL
8.40	.30	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
8.45	.00	.2	.00	.2	.00	.1	.00	.2	.00	.1	.00	.1
8.50	.00	.2	.00	.2	.00	.1	.00	.3	.00	.2	.00	.2
8.55	.00	.2	.00	.3	.00	.2	.00	.3	.00	.3	.00	.3
9.0	.00	.3	.00	.3	.00	.2	.00	.4	.00	.4	.01	.4
9.05	.00	.3	.00	.4	.00	.3	.00	.5	.01	.5	.01	.5
9.10	.00	.3	.01	.5	.01	.4	.02	.6	.01	.5	.01	.5
9.15	.02	.4	.01	.6	.02	.5	.03	.8	.03	.6	.03	.6
9.20	.01	.5	.03	.8	.04	.7	.06	.9	.04	.7	.04	.7
9.25	.02	.7	.06	1.0	.06	.8	.07	.9	.05	.8	.05	.8
9.30	.06	.7	.09	1.1	.08	.9	.09	1.0	.06	.9	.06	.9
9.35	.10	1.1	.11	1.1	.10	1.0	.11	1.1	.08	.9	.05	.7
9.40	.13	1.2	.15	1.1	.14	1.1	.14	1.2	.10	1.0	.07	.8
9.45	.17	1.3	.18	1.2	.17	1.1	.17	1.2	.12	1.1	.08	.8
9.50	.21	1.3	.22	1.3	.19	1.2	.19	1.3	.14	1.1	.09	.9
9.55	.24	1.4	.24	1.3	.22	1.3	.21	1.3	.15	1.1	.10	.9
10.0	.27	1.4	.27	1.3	.24	1.2	.23	1.3	.16	1.2	.11	.9
10.05	.29	1.5	.28	1.4	.25	1.3	.23	1.3	.16	1.2	.11	.9
10.10	.29	1.5	.27	1.3	.24	1.2	.21	1.2	.15	1.1	.10	.9
10.15	.27	1.4	.25	1.3	.21	1.2	.18	1.2	.13	1.1	.09	.8
10.20	.24	1.4	.21	1.2	.18	1.1	.16	1.1	.11	1.1	.07	.8
10.25	.21	1.3	.18	1.1	.16	1.1	.13	1.1	.10	1.0	.06	.7
10.30	.18	1.3	.16	1.1	.13	1.0	.11	1.0	.08	1.0	.05	.7
10.35	.16	1.2	.14	1.0	.12	1.0	.10	1.0	.08	1.0	.05	.7
10.40	.15	1.2	.14	1.1	.13	1.0	.13	1.1	.10	1.0	.07	.8
10.45	.17	1.3	.17	1.2	.16	1.1	.17	1.2	.12	1.1	.08	.8
10.50	.20	1.3	.20	1.2	.18	1.1	.18	1.2	.12	1.1	.08	.8
10.55	.22	1.4	.21	1.2	.19	1.1	.17	1.2	.12	1.1	.08	.8
11.0	.22	1.4	.21	1.2	.18	1.1	.16	1.1	.11	1.1	.07	.8
11.05	.21	1.3	.19	1.2	.16	1.1	.14	1.1	.10	1.0	.07	.8
11.10	.19	1.3	.17	1.1	.15	1.1	.13	1.1	.09	1.0	.06	.7
11.15	.17	1.3	.16	1.1	.12	1.0	.12	1.0	.08	1.0	.05	.7
11.20	.16	1.2	.14	1.1	.12	1.0	.11	1.0	.08	.9	.05	.7
11.25	.14	1.2	.13	1.0	.11	1.0	.10	1.0	.07	.9	.05	.7
11.30	.13	1.2	.12	1.0	.10	1.0	.09	1.0	.06	.9	.04	.7
11.35	.12	1.1	.11	1.0	.09	.9	.08	.9	.06	.9	.04	.7
11.40	.11	1.1	.10	.9	.08	.9	.07	.9	.05	.9	.03	.5

TABLE III-15
 TIME HISTORY OF FLOWS AND VELOCITIES

SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1
 EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

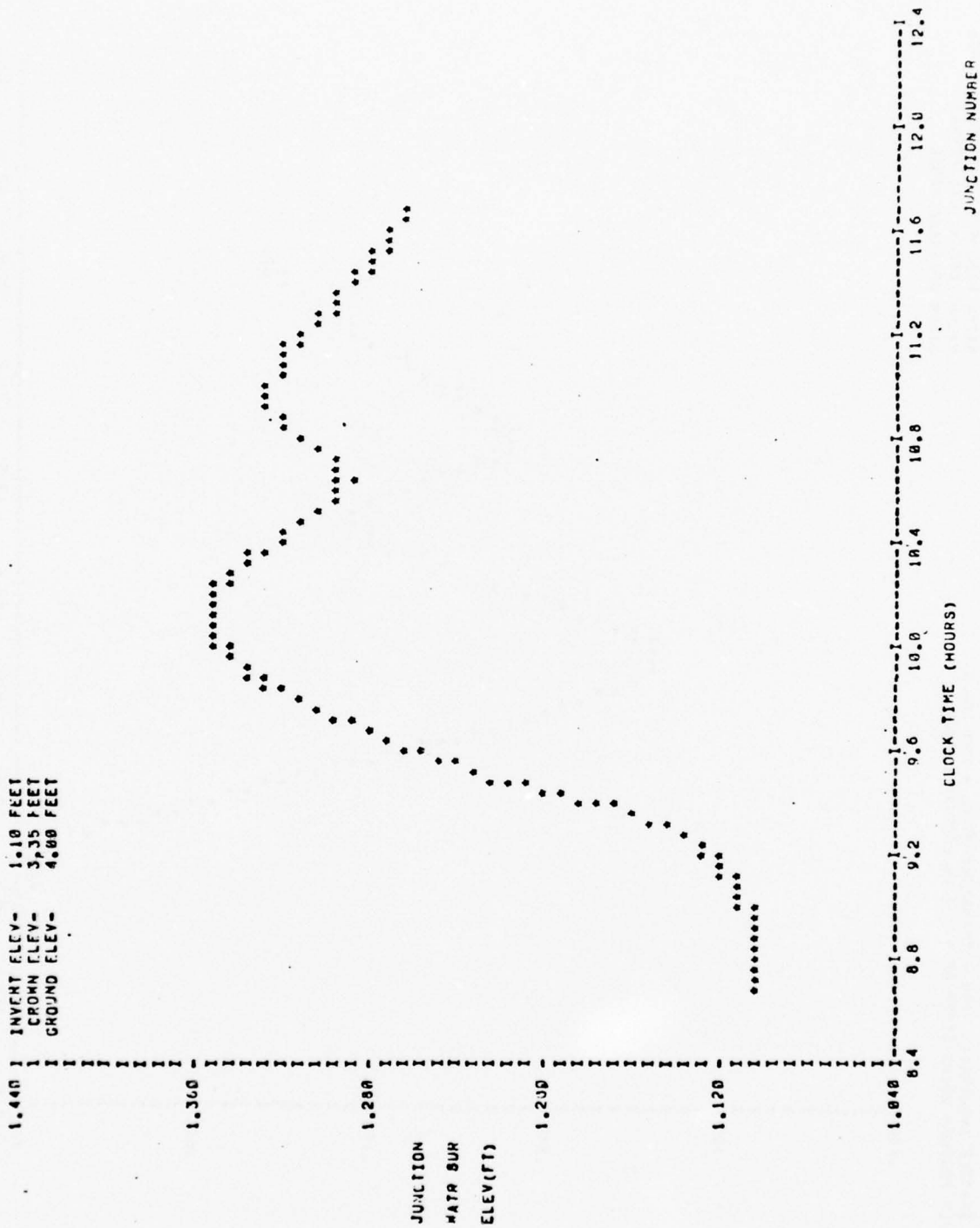


FIGURE III-10 TIME HISTORY OF WATER SURFACE ELEVATION

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE MODEL

SOUTH SEATTLE INDUSTRIAL PARK - TRANSPORT MODEL - RUN NO. 1
EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL

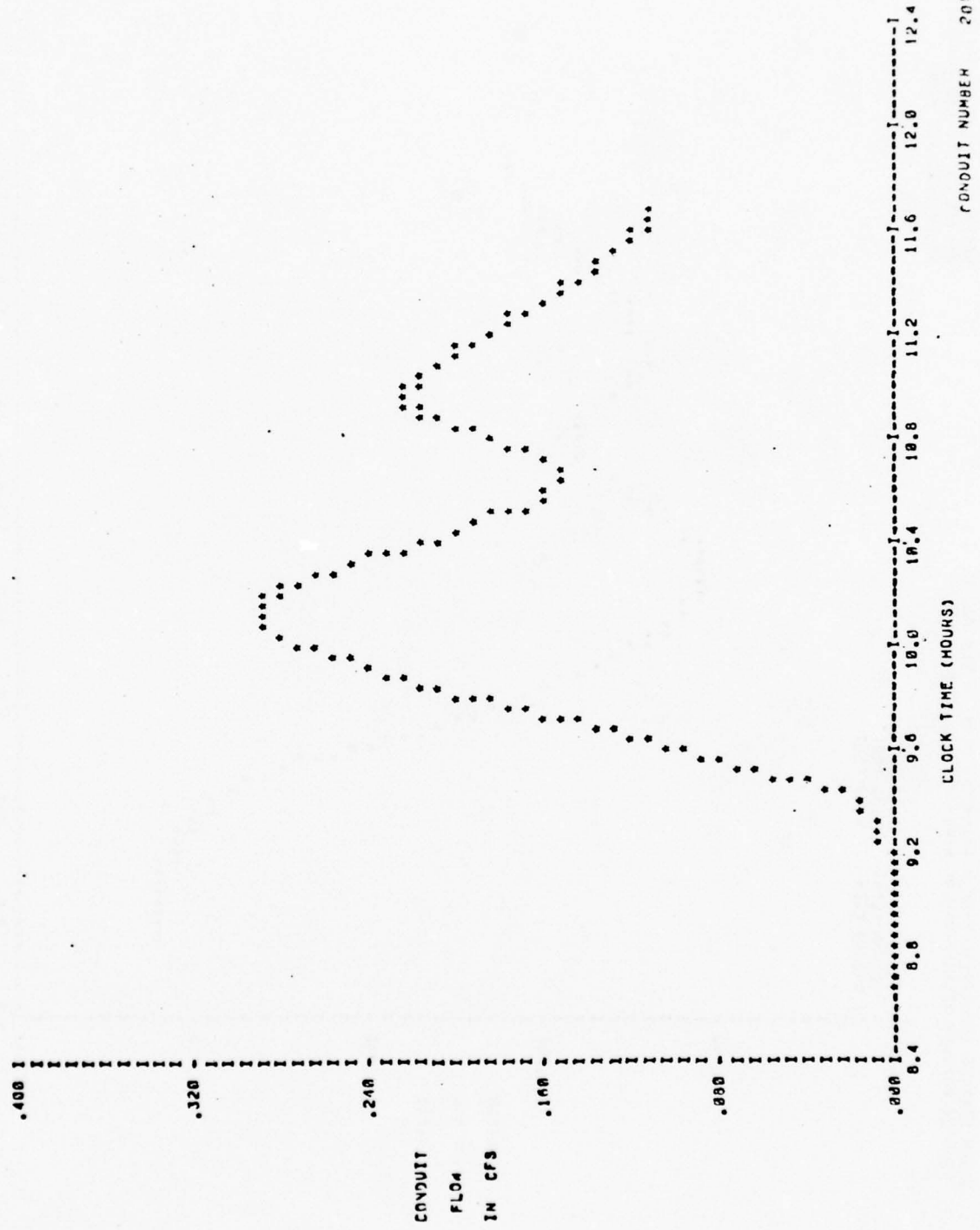


FIGURE III-11 TIME HISTORY OF CONDUIT FLOW

Transport Quality Block

An example problem is now given for the Transport Quality Block. The South Seattle Industrial Park calibration area drainage system is used as an example. The pollutographs generated from the Runoff Block are transferred through the Transport Block and, along with the hydraulic results from the Transport model, are used as input data to the Transport Quality model. The Transport Quality model does not require additional specific data except for run control parameters. The data control parameters must correlate to those used in the Transport Block.

The data card listing is presented in Table III-16 and examples of program output are presented in Tables III-17 through III-22. Tables III-16 and III-17 recap the input data and Tables III-18 through III-22 indicate typical time histories of quality.

If the user desires a complete history of quality behavior the constituents are plotted in the following order:

- | | |
|---------------------------|-----------------------|
| 1. Settleable Solids | 12. Organic Nitrogen |
| 2. Suspended Solids | 13. Nitrate + Nitrite |
| 3. Total Dissolved Solids | 14. Total Phosphate |
| 4. 5-day BOD | 15. Ortho Phosphate |
| 5. Chemical Oxygen Demand | 16. Mercury |
| 6. Chlorides | 17. Copper |
| 7. Sulfates | 18. Zinc |
| 8. Grease | 19. Lead |
| 9. Total Coliform | 20. Chromium |
| 10. Fecal Coliform | 21. Cadmium |
| 11. Ammonia | 22. Arsenic |

Typical printer plots for the mass emission rates of settleable solids and BOD are indicated for junction 1 in Figures III-12 and III-13, respectively.

CARD GROUP

SOUTH SEATTLE INDUSTRIAL PARK - TRANS-GUAL MODEL - RUN NO. 1									
EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL									
1	1000	10	840	5	1	30	15	CUTQAL	12
2									SEHYD
3		1	2	2	3	4	5		
4	111	1	1						
5		1		7					
6	11	1	1	1	1				

TABLE III-16
QUALITY TRANSPORT BLOCK EXAMPLE PROBLEM INPUT DATA

SOUTH SEATTLE INDUSTRIAL PARK - TRANS-QUAL MODEL - RUN NO. 1
 EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE QUALITY MODEL

INTEGRATION CYCLES 1000
 LENGTH OF INTEGRATION STEP IS 10. SECONDS
 PRINTING STARTS IN CYCLE 1 AND PRINTS AT INTERVALS OF 30 CYCLES
 INITIAL TIME IS 8.67 HOURS

POLLUTOGRAPHS WILL BE PRINTED AT 5 JUNCTIONS.

1	2	3	4	5
---	---	---	---	---

LIST CODES ARE

0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0

POLLUTOGRAPHS WILL BE PLOTTED AT 2 JUNCTIONS.

1	7
---	---

PLOT CODES ARE

1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0

INPUT POLLUTOGRAPHS (TAPE) AT 6 JUNCTIONS.

7	6	5	3	2	4
---	---	---	---	---	---

TABLE III-17
 PRINTED CONTROL DATA

SOUTH SEATTLE INDUSTRIAL PARK - TRANS-DUAL MODEL - RUN NO. 1
EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE QUALITY MODEL

TIME HR:MIN	1					2					3					4					5							
	JUNCTION	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	JUNCTION	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	JUNCTION	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	JUNCTION	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	JUNCTION	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	JUNCTION	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	JUNCTION	CONC MG/L	EMISSION RATE LB/S	FLOW CFS
8:40		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00
8:45		.00	.00	.000		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00
8:50		.00	.00	.000		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00
8:55		.00	.00	.000		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00
9:00		.00	.00	.000		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00
9:05		.00	.00	.000		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00
9:10		.00	.00	.000		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00		.00	.000	.00
9:15		.00	.82	.000		.00	.000	.01		.01	.000	.01		.01	.000	.02		.02	.000	.02		.02	.000	.02		.02	.000	.42
9:20		.01	5.98	.000		.01	25.81	.000		.02	16.69	.000		.02	16.69	.000		.02	16.69	.000		.02	16.69	.000		.02	16.69	.000
9:25		.02	13.43	.000		.02	39.97	.000		.05	26.43	.000		.05	26.43	.000		.05	26.43	.000		.05	26.43	.000		.05	26.43	.000
9:30		.06	19.62	.000		.06	46.19	.000		.09	36.13	.000		.09	36.13	.000		.09	36.13	.000		.09	36.13	.000		.09	36.13	.000
9:35		.10	32.30	.000		.10	55.42	.000		.11	47.46	.000		.11	47.46	.000		.11	47.46	.000		.11	47.46	.000		.11	47.46	.000
9:40		.13	45.13	.000		.13	65.21	.000		.15	57.38	.000		.15	57.38	.000		.15	57.38	.000		.15	57.38	.000		.15	57.38	.000
9:45		.17	54.63	.000		.17	70.70	.000		.18	62.11	.000		.18	62.11	.000		.18	62.11	.000		.18	62.11	.000		.18	62.11	.000
9:50		.21	61.45	.000		.21	73.45	.000		.22	64.37	.000		.22	64.37	.000		.22	64.37	.000		.22	64.37	.000		.22	64.37	.000
9:55		.24	65.45	.000		.24	73.46	.000		.24	65.36	.000		.24	65.36	.000		.24	65.36	.000		.24	65.36	.000		.24	65.36	.000
10:00		.27	67.38	.000		.27	72.67	.000		.27	65.40	.000		.27	65.40	.000		.27	65.40	.000		.27	65.40	.000		.27	65.40	.000
10:05		.29	68.38	.000		.29	70.75	.000		.28	64.74	.000		.28	64.74	.000		.28	64.74	.000		.28	64.74	.000		.28	64.74	.000
10:10		.29	69.08	.000		.29	68.23	.000		.29	68.23	.000		.29	68.23	.000		.29	68.23	.000		.29	68.23	.000		.29	68.23	.000
10:15		.27	68.85	.000		.27	66.43	.000		.25	62.97	.000		.25	62.97	.000		.25	62.97	.000		.25	62.97	.000		.25	62.97	.000
10:20		.24	68.62	.000		.24	65.31	.000		.21	62.49	.000		.21	62.49	.000		.21	62.49	.000		.21	62.49	.000		.21	62.49	.000
10:25		.21	68.38	.000		.21	64.63	.000		.18	62.25	.000		.18	62.25	.000		.18	62.25	.000		.18	62.25	.000		.18	62.25	.000
10:30		.18	67.62	.000		.18	63.66	.000		.16	62.30	.000		.16	62.30	.000		.16	62.30	.000		.16	62.30	.000		.16	62.30	.000
10:35		.16	65.05	.000		.16	61.07	.000		.14	59.88	.000		.14	59.88	.000		.14	59.88	.000		.14	59.88	.000		.14	59.88	.000
10:40		.15	61.99	.000		.15	61.59	.000		.15	60.06	.000		.14	60.06	.000		.13	61.95	.000		.13	61.95	.000		.13	61.95	.000
10:45		.17	59.63	.000		.17	64.18	.000		.17	61.48	.000		.17	61.48	.000		.16	64.42	.000		.16	64.42	.000		.16	64.42	.000
10:50		.20	59.90	.000		.20	67.23	.000		.20	62.52	.000		.20	62.52	.000		.18	64.13	.000		.18	64.13	.000		.18	64.13	.000
10:55		.22	62.93	.000		.22	68.22	.000		.22	68.22	.000		.21	62.76	.000		.19	62.81	.000		.17	60.25	.000		.17	60.25	.000
11:00		.22	66.24	.000		.22	67.17	.000		.21	62.45	.000		.21	62.45	.000		.18	61.89	.000		.16	60.44	.000		.16	60.44	.000
11:05		.21	67.32	.000		.21	65.57	.000		.19	62.00	.000		.19	62.00	.000		.16	61.49	.000		.14	59.92	.000		.14	59.92	.000
11:10		.19	66.85	.000		.19	64.65	.000		.17	61.86	.000		.17	61.86	.000		.15	61.32	.000		.13	59.84	.000		.13	59.84	.000
11:15		.18	66.49	.000		.18	64.17	.000		.16	61.86	.000		.16	61.86	.000		.13	61.24	.000		.12	59.77	.000		.12	59.77	.000
11:20		.16	66.23	.000		.16	63.90	.000		.14	61.57	.000		.14	61.57	.000		.12	61.25	.000		.11	59.71	.000		.11	59.71	.000
11:25		.14	65.99	.000		.14	63.16	.000		.13	60.90	.000		.13	60.90	.000		.11	61.07	.000		.10	59.45	.000		.10	59.45	.000
11:30		.13	63.47	.000		.13	59.71	.000		.12	58.46	.000		.12	58.46	.000		.09	59.26	.000		.09	59.26	.000		.09	59.26	.000
11:35		.12	60.37	.000		.12	56.83	.000		.11	56.38	.000		.11	56.38	.000		.09	57.35	.000		.08	58.02	.000		.08	58.02	.000

TABLE III-18
COMPUTED TIME HISTORY, SETTLEABLE SOLIDS

SOUTH SEATTLE INDUSTRIAL PARK - TRANS-QUAL MODEL - RUN NO.1
EXAMPLE PROBLEM USING STOR4 OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE QUALITY MODEL

TIME HR:MIN	TIME HISTORY OF										I.D.S.										
	JUNCTION 1		JUNCTION 2		JUNCTION 3		JUNCTION 4		JUNCTION 5		JUNCTION 6		JUNCTION 7		JUNCTION 8		JUNCTION 9		JUNCTION 10		
	FLOW CFS	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	CONC MG/L	EMISSION RATE LB/S	FLOW CFS	CONC MG/L	EMISSION RATE LB/S
8:43	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
8:45	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
8:50	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
8:55	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:00	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:05	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:10	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:15	.00	2.67	.000	.00	27.51	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:20	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:25	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:30	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:35	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:40	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:45	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:50	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
9:55	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:00	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:05	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:10	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:15	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:20	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:25	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:30	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:35	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:40	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:45	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:50	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
10:55	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:00	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:05	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:10	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:15	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:20	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:25	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:30	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000
11:35	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000	.00	.00	.000

TABLE III-20
COMPUTED TIME HISTORY, TDS

SOUTH SEATTLE INDUSTRIAL PARK - TRANS-QUAL MODEL - RUN NO. 1
EXAMPLE PROBLEM USING STORM OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE QUALITY MODEL

TIME HISTORY OF TOTAL COLIFORMS																					
JUNCTION 1				JUNCTION 2				JUNCTION 3				JUNCTION 4				JUNCTION 5					
TIME HR./MIN	FLOW CFS	CONC MPN	RATE MP/S	FLOW CFS	CONC MPN	RATE MP/S	FLOW CFS	CONC MPN	RATE MP/S	FLOW CFS	CONC MPN	RATE MP/S	FLOW CFS	CONC MPN	RATE MP/S	FLOW CFS	CONC MPN	RATE MP/S	FLOW CFS	CONC MPN	RATE MP/S
8:40	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00
8:45	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00
8:50	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00
8:55	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00
9:0	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00	.00	0.00	0.00
9:5	.00	2.35+09	1.83-16	.00	2.56+07	1.96-14	.00	2.85+05	6.57-12	.00	3.35+03	8.03-10	.01	1.44+01	8.01-08	.01	1.44+01	8.01-08	.01	1.44+01	8.01-08
9:10	.00	2.85+04	3.83-11	.00	6.31+03	8.47-10	.01	1.99+00	7.82-07	.01	5.95+00	2.74-06	.02	1.42+02	1.43-04	.02	1.42+02	1.43-04	.02	1.42+02	1.43-04
9:15	.00	2.79+02	7.49-05	.00	2.87+03	7.71-04	.01	1.60+03	1.39-03	.02	2.02+03	1.96-03	.03	5.12+03	1.04-02	.03	5.12+03	1.04-02	.03	5.12+03	1.04-02
9:20	.01	2.04+03	1.16-03	.01	8.80+03	4.09-03	.02	5.69+03	8.79-03	.04	6.58+03	1.44-02	.05	1.07+04	3.15-02	.05	1.07+04	3.15-02	.05	1.07+04	3.15-02
9:25	.02	4.57+03	6.08+03	.02	1.36+04	1.81-02	.05	8.87+03	3.03-02	.05	1.08+04	4.10-02	.07	1.56+04	6.16-02	.07	1.56+04	6.16-02	.07	1.56+04	6.16-02
9:30	.06	6.69+03	2.87-02	.06	1.57+04	6.04-02	.09	1.23+04	7.02-02	.09	1.60+04	8.04-02	.09	1.96+04	1.06-01	.09	1.96+04	1.06-01	.09	1.96+04	1.06-01
9:35	.10	1.69+04	6.67-02	.10	1.89+04	1.14-01	.11	1.62+04	1.15-01	.11	1.62+04	1.15-01	.11	2.07+04	1.13-01	.11	2.07+04	1.13-01	.11	2.07+04	1.13-01
9:40	.13	1.54+04	1.24-01	.13	2.22+04	1.79-01	.13	1.96+04	1.78-01	.14	2.04+04	1.30-01	.14	2.04+04	1.30-01	.14	2.04+04	1.30-01	.14	2.04+04	1.30-01
9:45	.17	1.80+04	1.90-01	.17	2.41+04	2.54-01	.18	2.12+04	2.41-01	.18	2.26+04	2.34-01	.17	2.12+04	2.19-01	.17	2.12+04	2.19-01	.17	2.12+04	2.19-01
9:50	.21	2.09+04	2.73-01	.21	2.53+04	3.26-01	.22	2.19+04	2.96-01	.22	2.19+04	2.96-01	.19	2.26+04	2.74-01	.19	2.13+04	2.17-01	.19	2.13+04	2.17-01
9:55	.24	2.23+04	3.26-01	.24	2.50+04	3.77-01	.27	2.48+04	4.17-01	.27	2.48+04	4.17-01	.22	2.24+04	3.02-01	.21	2.14+04	2.79-01	.21	2.14+04	2.79-01
10:0	.27	2.30+04	3.87-01	.27	2.48+04	4.17-01	.27	2.48+04	4.17-01	.27	2.48+04	4.17-01	.24	2.22+04	3.29-01	.23	2.13+04	3.16-01	.23	2.13+04	3.16-01
10:5	.29	2.53+04	4.20-01	.29	2.41+04	4.35-01	.29	2.41+04	4.35-01	.29	2.41+04	4.35-01	.25	2.18+04	3.38-01	.25	2.13+04	3.16-01	.25	2.13+04	3.16-01
10:10	.29	2.50+04	4.25-01	.29	2.50+04	4.25-01	.29	2.50+04	4.25-01	.29	2.50+04	4.25-01	.24	2.15+04	3.16-01	.24	2.08+04	2.73-01	.24	2.08+04	2.73-01
10:15	.27	2.35+04	3.96-01	.27	2.26+04	3.83-01	.27	2.26+04	3.83-01	.25	2.15+04	3.30-01	.21	2.12+04	2.79-01	.18	2.07+04	2.38-01	.18	2.07+04	2.38-01
10:20	.24	2.34+04	3.92-01	.24	2.23+04	3.30-01	.24	2.23+04	3.30-01	.21	2.13+04	2.86-01	.18	2.11+04	2.40-01	.16	2.06+04	2.03-01	.16	2.06+04	2.03-01
10:25	.21	2.33+04	3.80-01	.21	2.20+04	2.89-01	.21	2.20+04	2.89-01	.18	2.12+04	2.44-01	.16	2.10+04	2.05-01	.13	2.06+04	1.73-01	.13	2.06+04	1.73-01
10:30	.19	2.31+04	2.61-01	.18	2.17+04	2.46-01	.16	2.12+04	2.09-01	.16	2.12+04	2.09-01	.13	2.10+04	1.75-01	.12	2.06+04	1.48-01	.12	2.06+04	1.48-01
10:35	.16	2.22+04	2.19-01	.16	2.08+04	2.06-01	.14	2.04+04	1.76-01	.14	2.04+04	1.76-01	.12	2.04+04	1.50-01	.10	2.12+04	1.98-01	.10	2.12+04	1.98-01
10:40	.15	2.21+04	2.01-01	.15	2.10+04	2.00-01	.14	2.04+04	1.76-01	.14	2.04+04	1.76-01	.13	2.10+04	1.68-01	.13	2.10+04	1.68-01	.13	2.10+04	1.68-01
10:45	.17	2.03+04	2.15-01	.17	2.19+04	2.31-01	.17	2.09+04	2.27-01	.17	2.09+04	2.27-01	.16	2.20+04	2.18-01	.17	2.12+04	2.18-01	.17	2.12+04	2.18-01
10:50	.20	2.14+04	2.53-01	.20	2.29+04	2.83-01	.20	2.29+04	2.83-01	.20	2.13+04	2.71-01	.18	2.19+04	2.51-01	.18	2.07+04	2.09-01	.18	2.07+04	2.09-01
10:55	.22	2.15+04	2.92-01	.22	2.33+04	3.16-01	.22	2.33+04	3.16-01	.21	2.14+04	2.85-01	.19	2.14+04	2.50-01	.19	2.05+04	2.19-01	.19	2.05+04	2.19-01
11:0	.22	2.26+04	3.09-01	.22	2.29+04	3.14-01	.21	2.13+04	2.73-01	.21	2.13+04	2.73-01	.18	2.11+04	2.34-01	.16	2.05+04	2.13-01	.16	2.05+04	2.13-01
11:5	.21	2.30+04	2.99-01	.21	2.24+04	2.91-01	.19	2.11+04	2.52-01	.19	2.11+04	2.52-01	.16	2.10+04	2.14-01	.14	2.04+04	1.84-01	.14	2.04+04	1.84-01
11:10	.19	2.27+04	2.74-01	.19	2.20+04	2.65-01	.17	2.11+04	2.28-01	.17	2.11+04	2.28-01	.15	2.09+04	1.93-01	.13	2.04+04	1.76-01	.13	2.04+04	1.76-01
11:15	.14	2.24+04	2.48-01	.18	2.19+04	2.35-01	.16	2.11+04	2.06-01	.17	2.11+04	2.06-01	.13	2.09+04	1.74-01	.12	2.04+04	1.58-01	.12	2.04+04	1.58-01
11:20	.16	2.26+04	2.24-01	.16	2.18+04	2.16-01	.14	2.10+04	1.85-01	.14	2.10+04	1.85-01	.12	2.09+04	1.57-01	.11	2.04+04	1.35-01	.11	2.04+04	1.35-01
11:25	.14	2.25+04	2.02-01	.14	2.15+04	1.93-01	.13	2.08+04	1.65-01	.13	2.08+04	1.65-01	.11	2.03+04	1.42-01	.10	2.03+04	1.22-01	.10	2.03+04	1.22-01
11:30	.13	2.10+04	1.76-01	.13	2.04+04	1.65-01	.12	2.04+04	1.65-01	.12	1.99+04	1.44-01	.10	2.03+04	1.26-01	.09	2.02+04	1.14-01	.09	2.02+04	1.14-01
11:35	.12	2.06+04	1.53-01	.12	1.94+04	1.44-01	.11	1.92+04	1.26-01	.11	1.92+04	1.26-01	.09	1.95+04	1.11-01	.08	1.98+04	9.83-02	.08	1.98+04	9.83-02

TABLE III-21
COMPUTED TIME HISTORY, BOD

SOUTH SEATTLE INDUSTRIAL PARK - TRANS-DUAL MODEL - RUN NO. 1
 EXAMPLE PROBLEM USING STORY OF MARCH 16, 1973 AT DIAGONAL

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE QUALITY MODEL

TIME HISTORY OF										NITRATES + 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SETTLEABLE SOLIDS

JUNCTION NO. 1

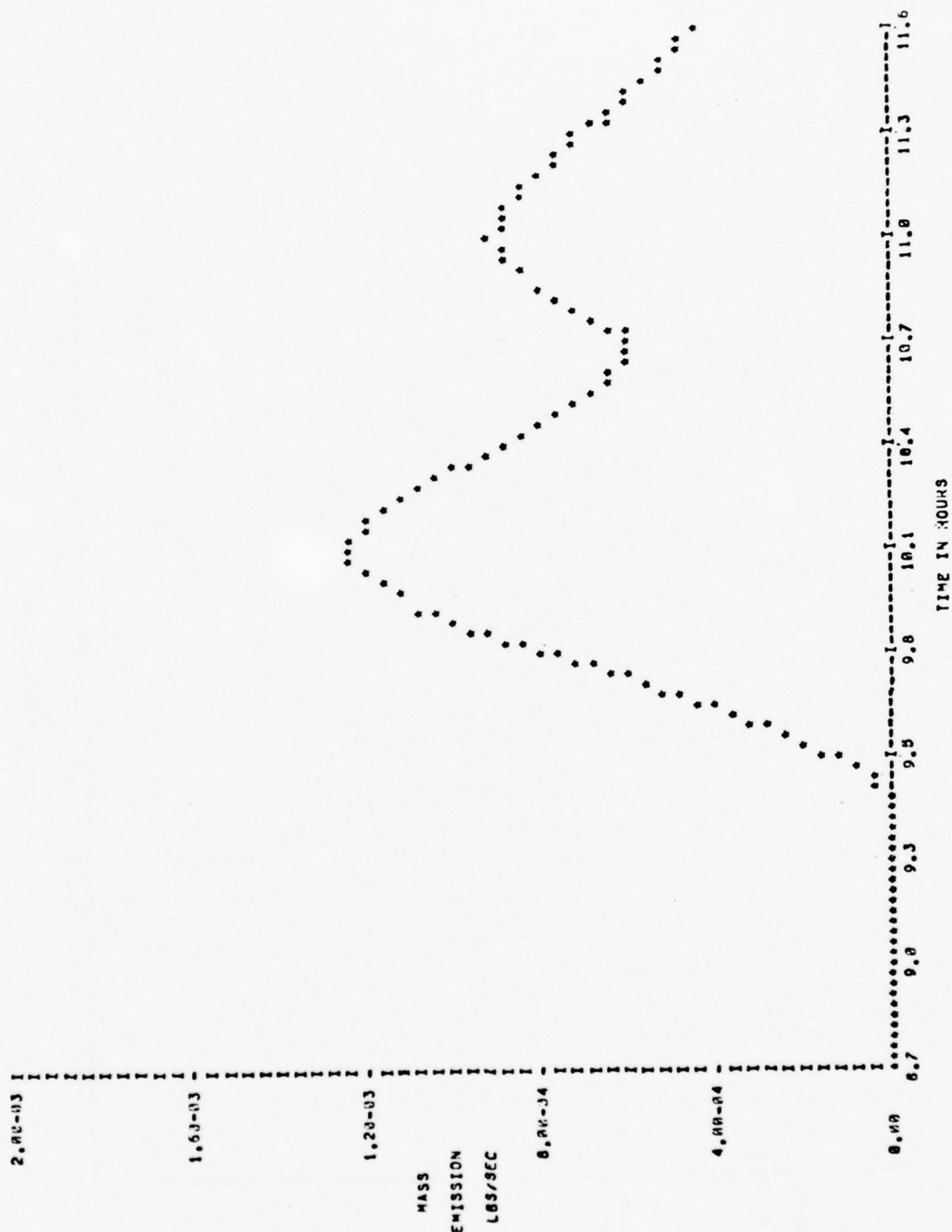


FIGURE III-12 COMPUTED TIME HISTORY, SETTLEABLE SOLIDS

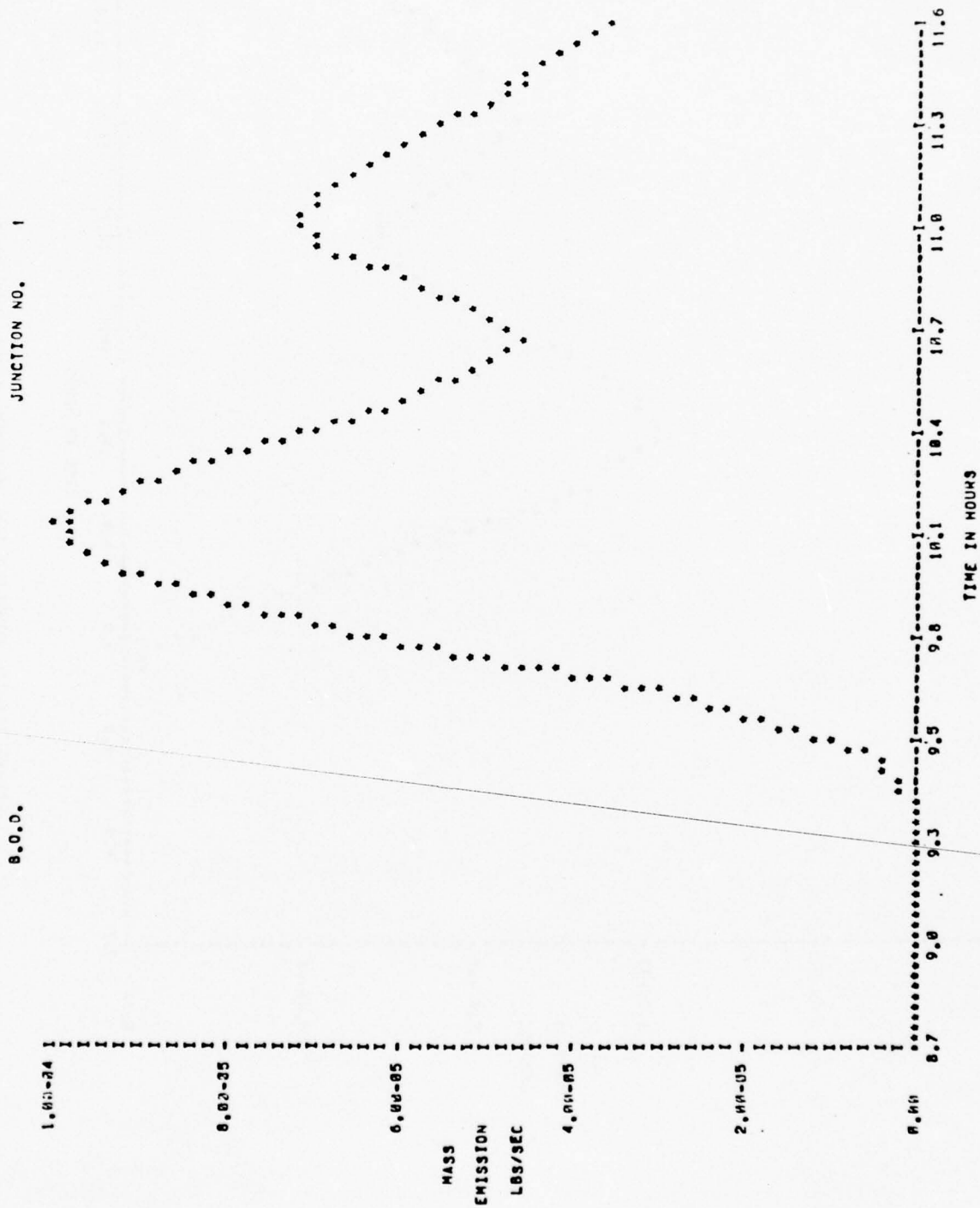


FIGURE III-13 COMPUTED TIME HISTORY, B.O.D.

SURFACE FLOODING CONDITIONS

Run 1 - Induced Flooding

An example problem of the Transport model's capability of surface flooding is given. The South Seattle Industrial Park storm drain pipe system, as shown in Figure III-2, is used as the example problem. Two runs are made, one to show flooding and a second to show a solution to the flooding problem. For the flooding example, Run 1, the capacity of the existing drainage system is overwhelmed with an input hydrograph placed at junction 7 which creates flooding at two junctions, 6 and 7. The data listing and results are shown in Tables III-23 through III-28 and Figures III-14 through III-17.

Table III-23 shows input card listings, while Tables III-24 and III-25 display the program's echo check of the input data. Table III-26 indicates the output produced in a flooding situation and shows the components of flow entering each flooded junction plus the total flooded volume in cubic feet. Table III-27 shows the history of the hydraulic grade line and Table III-28 indicates the time history of flows in the system conduits.

In Figures III-14 and III-15 we see plots of water surface elevations at junctions 2 and 7, and Figures III-16 and III-17 provide graphical displays of the flow in conduits 201 and 204. These results show that the maximum flooding volume at junction 7 is 1673 cubic feet and at junction 6 the maximum is 53 cubic feet. Using the maximum amount of flooding and a detailed contour map or volume-elevation table at a node, the user can determine the extent of flooding. With the volume of flooding known, the user can formulate plans to eliminate flooding or contain the flooding in a prescribed holding basin.

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM CHAINAGE MODEL

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

INTEGRATION CYCLES 90

LENGTH OF INTEGRATION STEP IS 10. SECONDS

PRINTING STARTS JP CYCLE 1 AND PRINTS AT INTERVALS OF 2 CYCLES

INITIAL TIME 6 HOURS, 0 MINUTES

PRINTED OUTPUT AT THE FOLLOWING 7 JUNCTIONS

1	2	3	4	5	6	7
---	---	---	---	---	---	---

AND FOR THE FOLLOWING 6 CONDUITS

201	202	203	204	205	206
-----	-----	-----	-----	-----	-----

WATER SURFACE ELEVATIONS WILL BE PLOTTED FOR THE FOLLOWING 2 JUNCTIONS

2	7
---	---

FLOW RATE WILL BE PLOTTED FOR THE FOLLOWING 2 CONDUITS

201	204
-----	-----

TABLE III-24
 PRINTED CONTROL DATA

	CONDUIT NUMBER	LENGTH (FT)	CLASS	AREA (SQ. FT)	MANNING (COEF.)	MAX WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT ENDS	TRAPEZOID SIDE SLOPE
1	201	430.	1	3.04	.015	2.25	2.25	1	.0
2	202	245.	1	3.14	.015	2.00	2.00	2	.0
3	203	310.	1	3.14	.015	2.00	2.00	3	.0
4	204	290.	1	2.41	.015	1.75	1.75	4	.0
5	205	300.	1	1.77	.015	1.50	1.50	5	.0
6	206	220.	1	1.77	.015	1.50	1.50	6	.0

CONNECTING CONDUITS

JUNCTION NUMBER	GROUND ELEV.	INVERT ELEV.	QINST (CFS)	CONNECTING CONDUITS
1	4.00	.10	.04	201
2	4.00	1.10	.02	202
3	4.50	1.90	.00	203
4	5.00	2.50	.00	204
5	5.50	3.40	.00	205
6	6.00	4.20	.00	206
7	7.00	4.60	.00	

FREE OUTFLOW AT JUNCTIONS.

1

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION	QINST (CFS)
7	1	0	

TABLE III-25
CONDUIT AND JUNCTION DATA

7	1419.	7.	206	6.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.
AT TIME (HOURS) .17 PRINT CYCLE 32 JUNCT SUM FLOOD 0 IN COND 0 COND 0 COND 0 COND 0 COND 0 COND 0 COND 0 COND 0 COND 0 COND 0																				
7	1422.	6.	206	6.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.
.33 5.00																				

TABLE III-26 (Continued)

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE MODEL

***** TIME HISTORY OF H. G. L. (VALUES IN FEET) *****

TIME HR. MIN	JUNCTION GRND ELEV	1 4.00 DEPTH	JUNCTION GRND ELEV	2 4.00 DEPTH	JUNCTION GRND ELEV	3 4.50 DEPTH	JUNCTION GRND ELEV	4 5.00 DEPTH	JUNCTION GRND ELEV	5 5.50 DEPTH	JUNCTION GRND ELEV	6 6.00 DEPTH
0. 0	1.10	.00	1.90	.00	2.50	.00	2.50	.00	3.40	.00	4.22	1.02
0. 0	1.10	.00	1.90	.00	2.50	.00	2.50	.00	3.40	.00	4.47	1.27
0. 1	1.10	.00	1.90	.00	2.50	.00	2.50	.00	3.44	.04	4.79	1.59
0. 1	1.10	.00	1.90	.00	2.50	.00	2.50	.00	3.56	.16	5.13	1.93
0. 1	1.10	.00	1.90	.00	2.51	.01	2.51	.01	3.73	.33	5.44	1.24
0. 2	1.10	.00	1.90	.00	2.56	.00	2.56	.00	3.95	.95	5.68	1.48
0. 2	1.10	.00	1.90	.00	2.65	.00	2.65	.15	4.16	.76	5.74	1.50
0. 2	1.10	.00	1.91	.00	2.78	.01	2.78	.28	4.33	.93	5.76	1.50
0. 3	1.10	.00	1.93	.01	2.93	.03	2.93	.43	4.46	1.06	5.77	1.50
0. 3	1.10	.00	1.90	.00	3.10	.09	3.10	.60	4.53	1.13	5.78	1.50
0. 3	1.10	.00	2.08	.00	3.25	.19	3.25	.75	4.56	1.16	5.80	1.50
0. 4	1.10	.00	2.19	.01	3.39	.29	3.39	.89	4.57	1.17	5.82	1.50
0. 4	1.14	.04	2.33	.04	3.50	.43	3.50	1.00	4.56	1.16	5.84	1.50
0. 4	1.19	.09	2.47	.09	3.57	.57	3.57	1.07	4.55	1.15	5.86	1.50
0. 5	1.27	.17	2.61	.17	3.61	.71	3.61	1.11	4.55	1.15	5.87	1.50
0. 5	1.37	.27	2.73	.27	3.63	.83	3.63	1.13	4.56	1.16	5.89	1.50
0. 5	1.47	.27	2.92	.27	3.64	.92	3.64	1.14	4.56	1.16	5.90	1.50
0. 6	1.58	.48	2.88	.48	3.65	.98	3.65	1.15	4.57	1.17	5.91	1.50
0. 6	1.69	.59	2.92	.59	3.66	1.02	3.66	1.16	4.58	1.18	5.92	1.50
0. 6	1.78	.68	2.94	.68	3.67	1.04	3.67	1.17	4.58	1.18	5.92	1.50
0. 7	1.87	.77	2.95	.77	3.69	1.05	3.69	1.19	4.59	1.19	5.93	1.50
0. 7	1.94	.84	2.95	.84	3.70	1.05	3.70	1.20	4.59	1.19	5.94	1.50
0. 8	2.00	.90	2.94	.90	3.71	1.04	3.71	1.21	4.59	1.19	5.95	1.50
0. 8	2.05	.95	2.94	.95	3.72	1.04	3.72	1.22	4.59	1.19	5.95	1.50
0. 8	2.09	.99	2.94	.99	3.72	1.04	3.72	1.22	4.59	1.19	5.96	1.50
0. 8	2.12	1.02	2.93	1.02	3.73	1.03	3.73	1.23	4.60	1.20	5.96	1.50
0. 9	2.15	1.05	2.93	1.05	3.73	1.03	3.73	1.23	4.60	1.20	5.96	1.50
0. 9	2.17	1.07	2.94	1.07	3.73	1.04	3.73	1.23	4.60	1.20	5.97	1.50
0. 9	2.18	1.08	2.94	1.08	3.73	1.04	3.73	1.23	4.60	1.20	5.97	1.50
0. 9	2.19	1.09	2.95	1.09	3.73	1.05	3.73	1.23	4.60	1.20	5.97	1.50
0.10	2.20	1.10	2.95	1.10	3.73	1.05	3.73	1.23	4.60	1.20	5.98	1.50
0.10	2.21	1.11	2.96	1.11	3.73	1.06	3.73	1.23	4.60	1.20	5.98	1.50
0.11	2.21	1.11	2.96	1.11	3.73	1.06	3.73	1.23	4.60	1.20	5.98	1.50
0.11	2.22	1.12	2.96	1.12	3.73	1.06	3.73	1.23	4.60	1.20	5.96	1.50
0.11	2.22	1.12	2.97	1.12	3.73	1.07	3.73	1.23	4.60	1.20	5.96	1.50
0.12	2.23	1.13	2.97	1.13	3.73	1.07	3.73	1.23	4.60	1.20	5.89	1.50
0.12	2.23	1.13	2.97	1.13	3.73	1.07	3.73	1.23	4.60	1.20	5.85	1.50
0.12	2.23	1.13	2.97	1.13	3.73	1.07	3.73	1.23	4.59	1.19	5.81	1.50
0.13	2.23	1.13	2.97	1.13	3.73	1.07	3.73	1.23	4.59	1.19	5.79	1.50
0.13	2.24	1.14	2.97	1.14	3.73	1.07	3.73	1.23	4.58	1.18	5.76	1.50
0.13	2.24	1.14	2.97	1.14	3.72	1.07	3.72	1.22	4.58	1.18	5.74	1.50
0.14	2.24	1.14	2.97	1.14	3.72	1.07	3.72	1.22	4.57	1.17	5.72	1.50
0.14	2.24	1.14	2.97	1.14	3.71	1.07	3.71	1.21	4.57	1.17	5.71	1.50
0.14	2.24	1.14	2.96	1.14	3.71	1.06	3.71	1.21	4.56	1.16	5.67	1.47
0.15	2.23	1.13	2.96	1.13	3.71	1.06	3.71	1.21	4.55	1.15	5.62	1.42

TABLE III-27 TIME HISTORY OF HYDRAULIC GRADE LINE

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIF. 94598
 STORM DRAINAGE MODEL

***** TIME HISTORY OF H. G. L. *****

JUNCTION
 6RND

JUNCTION 7
 6RND

TIME
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TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

***** TIME HISTORY OF FLOW AND VELOCITY *****													
TIME HR	MIN	CONDUIT FLOW	201 VEL	CONDUIT FLOW	202 VEL	CONDUIT FLOW	203 VEL	CONDUIT FLOW	204 VEL	CONDUIT FLOW	205 VEL	CONDUIT FLOW	206 VEL
0	0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	1	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	1	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	2	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	2	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	3	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	3	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	4	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	4	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	5	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	5	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	6	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	6	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	7	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	7	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	8	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	8	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	9	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	9	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	10	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	10	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	11	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	11	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	12	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	12	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	13	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	13	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	14	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	14	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0
0	15	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0

TABLE III-28 TIME HISTORY OF CONDUIT FLOWS AND VELOCITIES

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
 EXAMPLE PROFILE FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

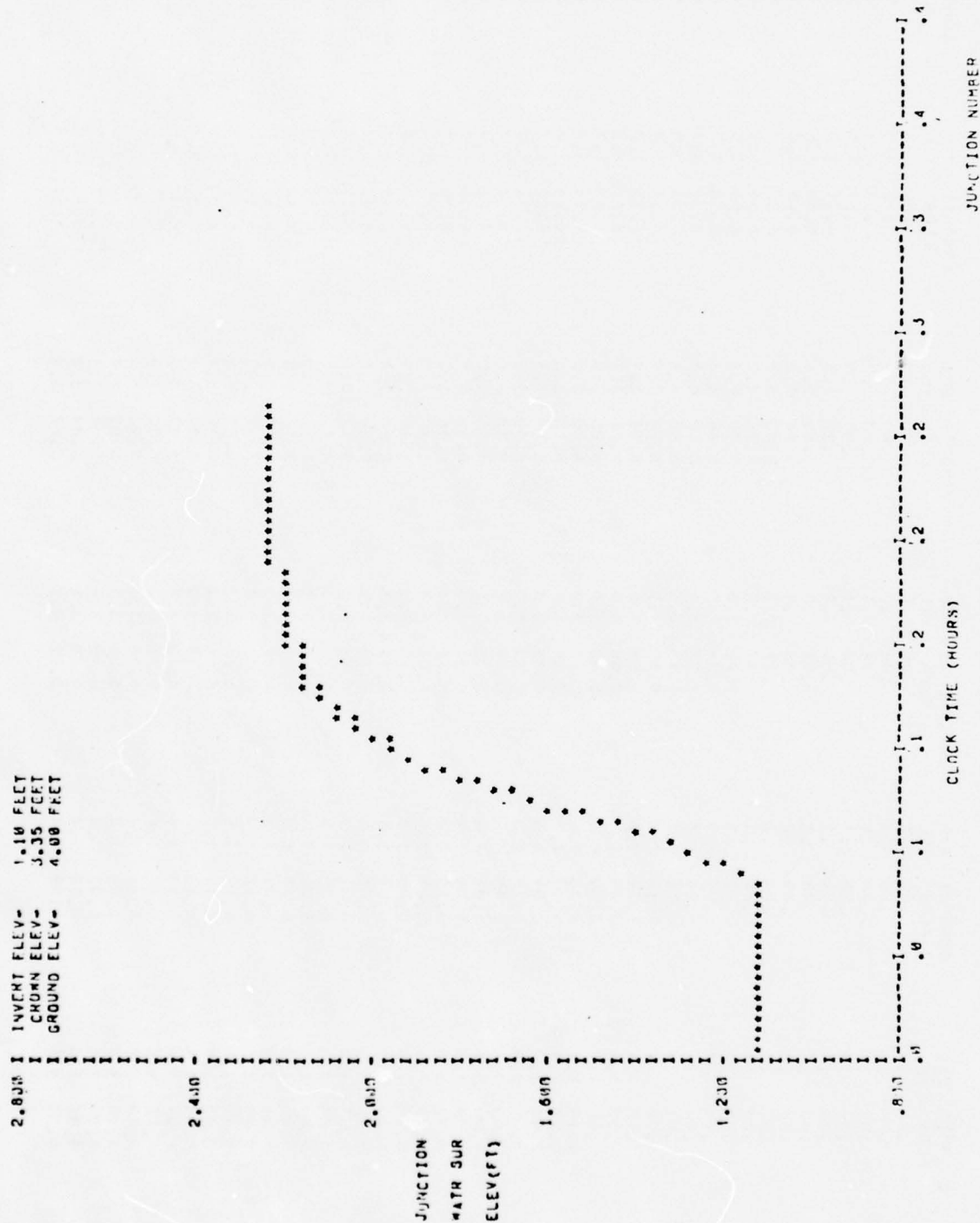


FIGURE III-14 TIME HISTORY OF WATER SURFACE ELEVATION, FLOODING RUN 1

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

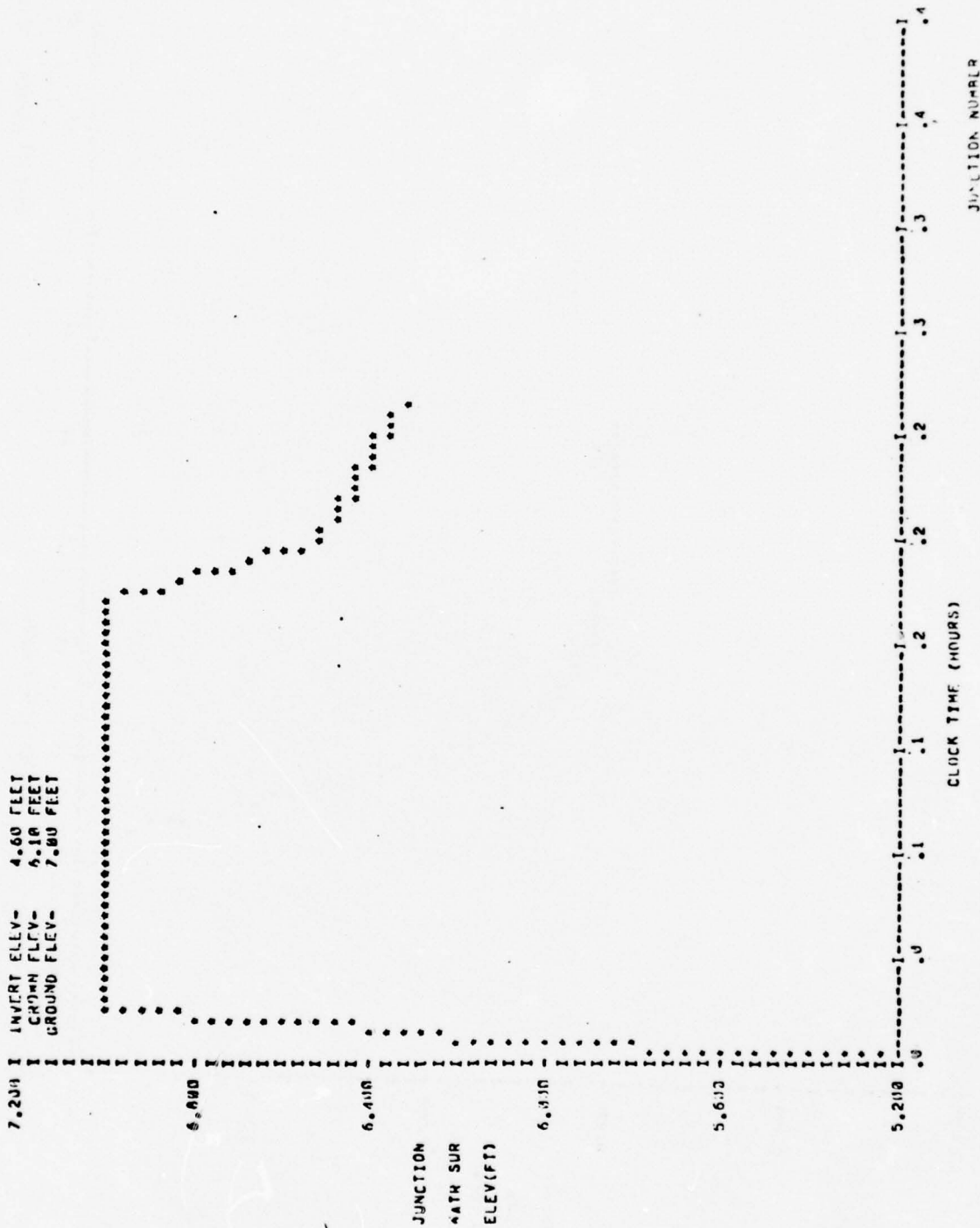


FIGURE III-15 TIME HISTORY OF WATER SURFACE ELEVATION, FLOODING RUN 1

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE MODEL

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

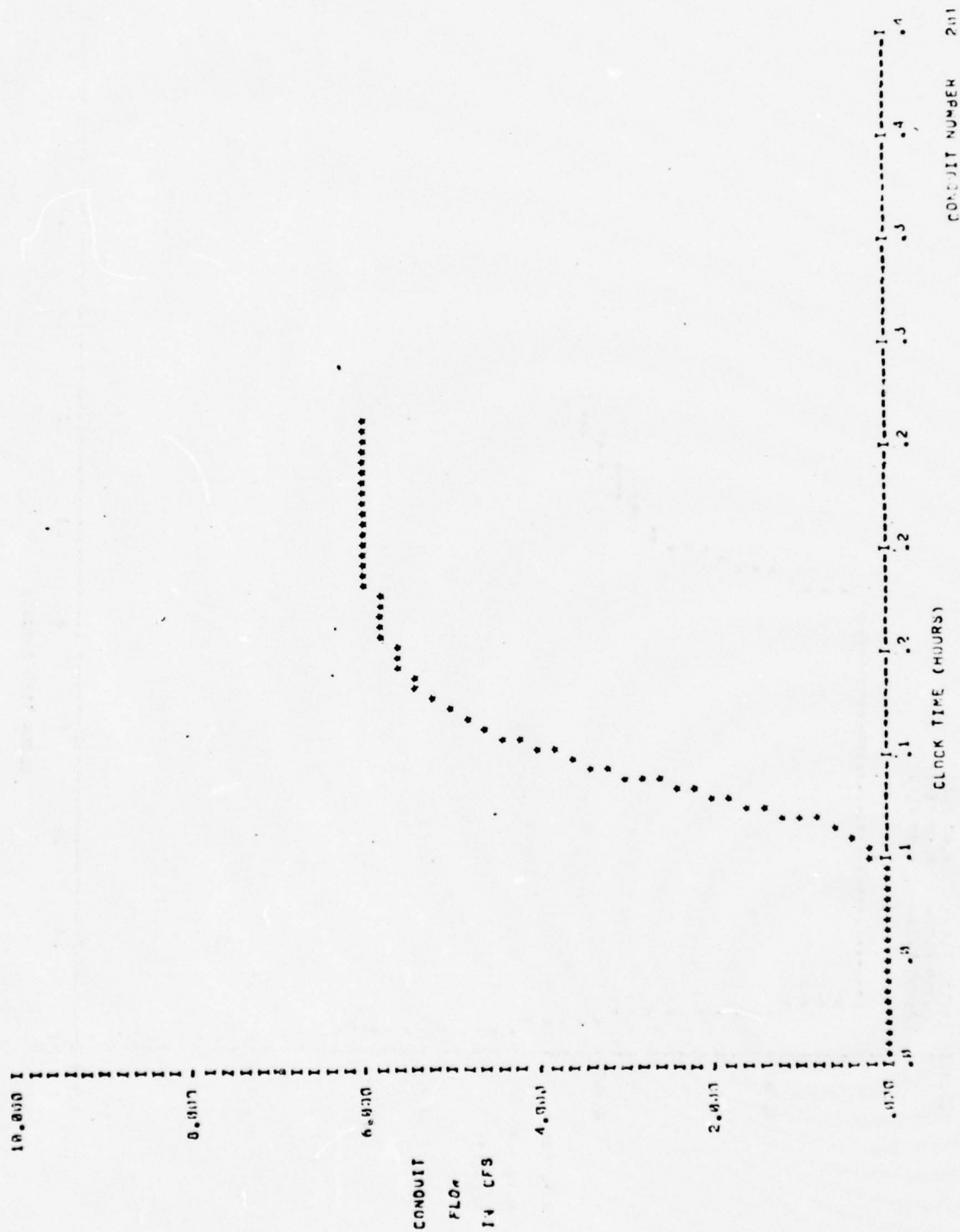


FIGURE III-16 TIME HISTORY OF CONDUIT FLOW, FLOODING RUN 1

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 1
 EXAMPLE PROGRAM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 PALM BEACH, CALIFORNIA
 STORM DRAINAGE MODEL

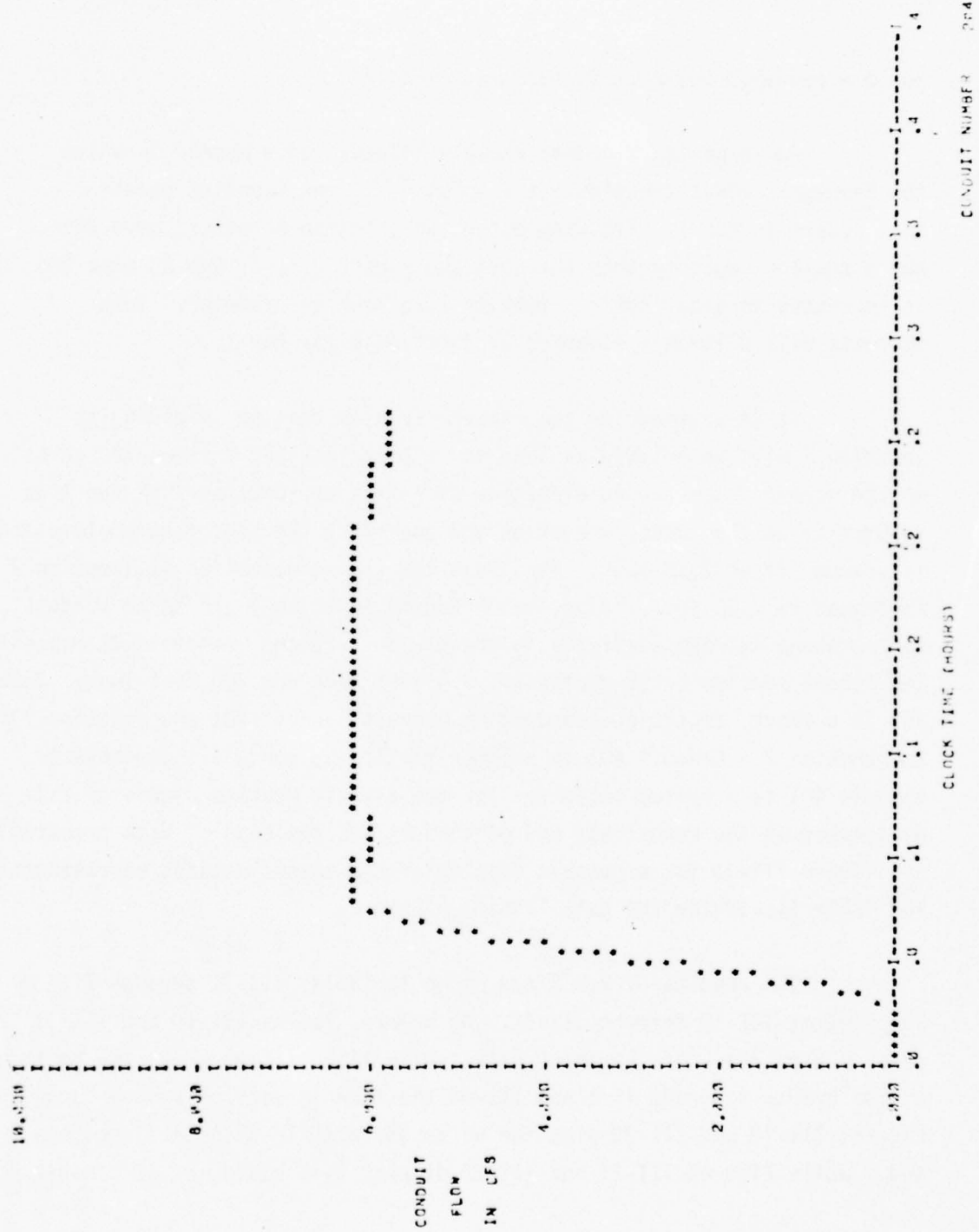


FIGURE III-17 TIME HISTORY OF CONDUIT FLOW, FLOODING RUN 1

Run 2 - Possible Solution to Flooding Problem

Run 2 of the flooding example illustrates a manner in which the Transport model can simulate a solution to the flooding problem that occurs in Run 1. Flooding occurs at junction 6 because pipe 205 has a smaller capacity than the upstream pipe 206. For Run 2, pipe 206 is increased in size from 1.5 feet to 1.75 feet in diameter. This increase will eliminate flooding at junction 6 for Run 2.

It is assumed for the example problem that any flooding at junction 7 will be allowed as long as it is maintained between the curbs of the street. The ground elevation of 7 feet at junction 7 in Run 1 is assumed to be the gutter elevation and therefore the top of curb elevation is assumed to be 7.50 feet. For Run 2 the ground elevation at junction 7 is raised to 7.50 feet. Also, connected to junction 7 are three conduits to represent storage available in the street section. Conduit 401 represents the street section as 50 feet wide, 0.5 feet deep and 200 feet long. Conduit 301 is a short, fictitious conduit to connect conduit 401 and junction 101 to junction 7. Conduit 402 is another fictitious conduit that connects conduit 401 to a system outfall. For the example problem, junction 1 is designated as the downstream end of conduit 402 for ease of data preparation. See Figure III-18 for a graphic display of the street section representation and Table III-29 for the data listing of Run 2.

The results of Run 2 are shown in Tables III-30 through III-33 and Figures III-19 through III-22. As before, Tables III-30 and III-31 give an echo check of the input data, while Table III-32 shows the position of the hydraulic grade line and III-33 the flow in various system conduits. Figures III-19 and III-20 plot the water surface elevation at junctions 2 and 7 while Figures III-21 and III-22 display time histories of conduit flow.

There is no flooding in Run 2 for the revised system using the same input hydrograph as in Run 1. The water surface elevation at junction 7

risers to a peak of 7.20 feet and recedes with the reduction of flow from the input hydrograph. The printout of the flow in conduit 301 shows water filling the street section initially and then later draining from the street section. A negative flow in a conduit means that the flow is from the junction with a lower invert elevation to a junction with a higher invert elevation; in the example this is from junction 7 to junction 101. Zero flow is shown for a conduit 401 and 402 because junction 102 is not wetted during the example problem.

Before leaving the subject of surface flooding, one additional item should be mentioned: stationary surface flooding. If a gutter or pipe becomes surcharged in a low area water will leave the system and it is often of interest to know the depth and extent of the expected flooding. To handle this problem the user need only specify a "dead end" storage element at the node in question and the model will simulate the inundation and draining of the surface area in accordance with the capacity and discharge of the basic sewer system. One can specify the stage-volume relationship of the flooded area by the appropriate selection of one or more equivalent trapezoidal sections and the model will produce the time history of water surface (surcharge) at the given nodes. With a little experience the user will find this method of estimating surface flooding both easy and efficient as no new types of data or changes in the basic computer codes is required.

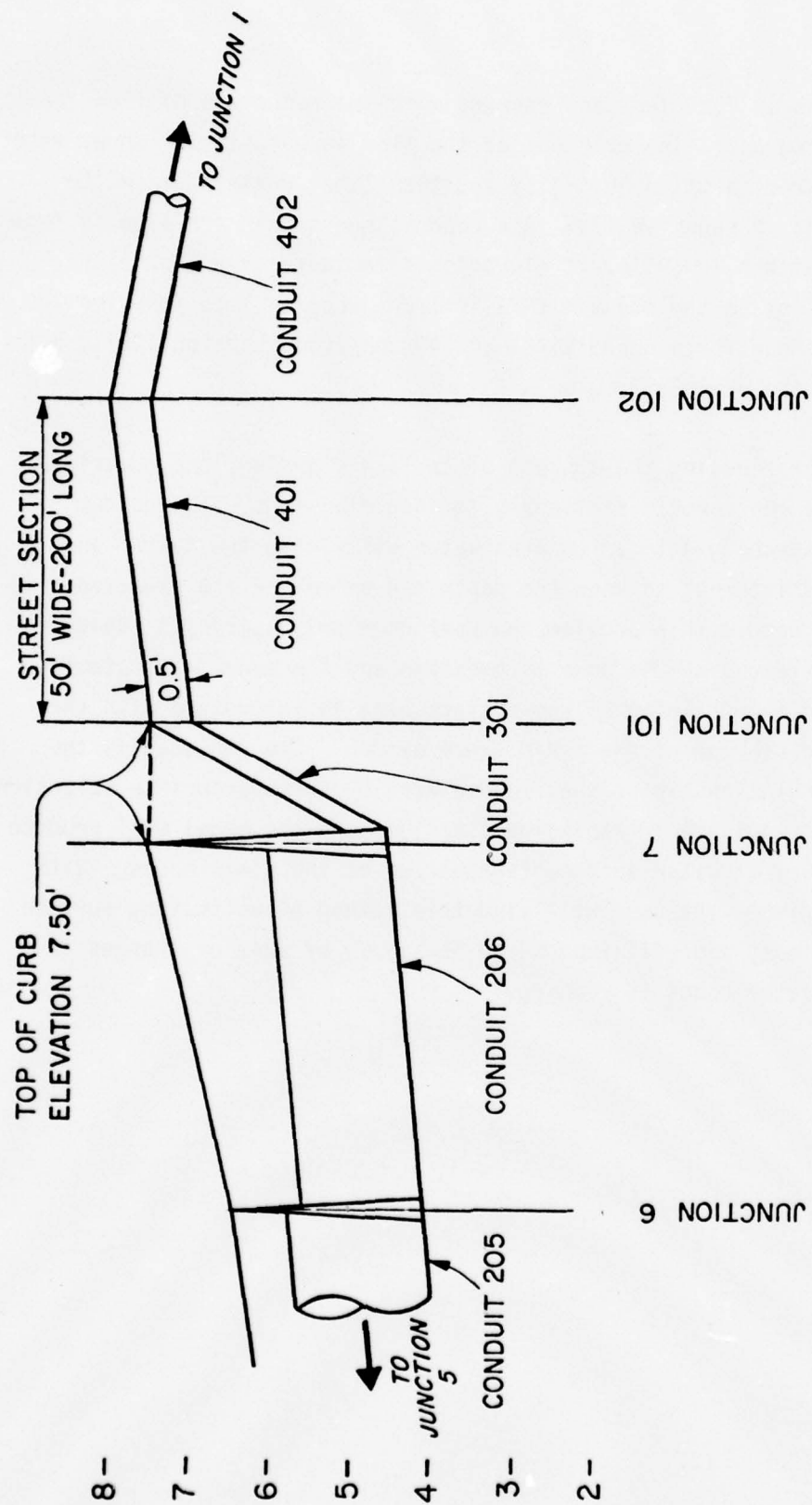


FIGURE III-18
PROFILE ALONG PIPE SYSTEM SHOWING STREET SECTION FOR USE AS FLOODING BASIN

12	101
7	401
301	

231	2	1	2.25	2.25	430	.015
232	3	2	2.0	2.0	245	.015
233	4	3	2.0	2.0	310	.015
234	5	4	1.75	1.75	200	.015
235	6	5	1.75	1.75	300	.015
236	7	6	1.5	1.5	220	.015
331	7	101	5	5	50	.015
401	101	102	0.5	50.	200	.015
432	102	1	0.5	0.5	100	.015

1	4.0	0.1
2	4.0	1.1
3	4.5	1.9
4	5.0	2.5
5	5.5	3.4
6	6.0	4.2
7	7.5	4.6
131	7.5	6.9
132	8.0	7.5

99999
99999
99999
99999
99999
99999
99999
99999
99999
99999

0.00	10
0.10	10
0.20	5
0.30	5

TABLE III-29
DEMONSTRATION FLOODING PROBLEM INPUT DATA, RUN 2

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 2
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

INTEGRATION CYCLES 20
 LENGTH OF INTEGRATION STEP IS 10. SECONDS
 PRINTING STARTS IN CYCLE 1 AND PRINTS AT INTERVALS OF 2 CYCLES
 INITIAL TIME 0 HOURS, 0 MINUTES
 PRINTED OUTPUT AT THE FOLLOWING 9 JUNCTIONS
 AND FOR THE FOLLOWING 9 CONDUITS
 201 202 203 204 205 206 301 401 402
 WATER SURFACE ELEVATIONS WILL BE PLOTTED FOR THE FOLLOWING 2 JUNCTIONS
 2 7
 FLOW RATE WILL BE PLOTTED FOR THE FOLLOWING 2 CONDUITS
 201 204

TABLE III-30
 PRINTED CONTROL DATA

CONDUIT NUMBER	LENGTH (FT)	CLASS	AREA (SQ FT)	MANNING COEFF.	MAX WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT ENDS	TRAPEZOID SIDE SLOPE
1	430.	1	3.08	.015	2.25	2.25	2	.0
2	245.	1	3.14	.015	2.00	2.00	3	.0
3	310.	1	3.14	.015	2.00	2.00	4	.0
4	204.	1	2.41	.015	1.75	1.75	5	.0
5	307.	1	2.41	.015	1.75	1.75	6	.0
6	220.	1	1.77	.015	1.50	1.50	7	.0
7	50.	2	2.00	.015	4.00	.50	7	.0
8	230.	2	22.50	.015	50.00	.45	101	.0
9	100.	1	.20	.015	.50	.50	102	.0

CONNECTING CONDUITS

CONDUIT	JUNCTION	GROUND ELEV.	INVERT ELEV.	INST (CFS)
1	1	4.00	.10	.00
2	2	4.00	1.10	.00
3	3	4.50	1.00	.00
4	4	5.00	2.50	.00
5	5	5.50	3.40	.00
6	6	6.00	4.20	.00
7	7	7.50	4.60	.00
8	101	7.50	6.90	.00
9	102	8.00	7.50	.00

FREE OUTFLOW AT JUNCTIONS.

1

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION	INVERT ELEV.	INST (CFS)
10	1	0		
JUNCTION NUMBER	GROUND ELEV.	INVERT ELEV.		

CONNECTING CONDUITS

INPUT HYDROGRAPHS (CARDS) AT 1 JUNCTIONS

7

TIME, HRS

JUNCTION INFLOWS IN CFS

.60
.00
.00
10.00
10.00
.10
5.00
5.00

TABLE III-31
CONDUIT, JUNCTION, AND INPUT HYDROGRAPH DATA

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 2
EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE MODEL

***** TIME HISTORY OF H. G. L. (VALUES IN FEET) *****									
TIME HR. MIN.	JUNCTION ELEV	JUNCTION GRND ELEV	JUNCTION DEPTH	JUNCTION ELEV	JUNCTION GRND ELEV	JUNCTION DEPTH	JUNCTION ELEV	JUNCTION GRND ELEV	JUNCTION DEPTH
0.0	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.0	1.13	1.90	.77	2.50	2.50	.00	3.40	3.40	.00
0.1	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.1	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.1	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.1	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.2	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.2	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.2	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.3	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.3	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.3	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.4	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.4	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.4	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.5	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.5	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.5	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.6	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.6	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.6	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.7	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.7	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.7	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.8	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.8	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.8	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.9	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.9	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
0.9	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.0	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.0	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.0	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.1	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.1	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.1	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.2	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.2	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.2	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.3	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.3	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.3	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.4	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.4	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.4	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00
1.5	1.10	1.90	.80	2.50	2.50	.00	3.40	3.40	.00

TABLE III-32 TIME HISTORY OF HYDRAULIC GRADE LINE

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 2
EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
WALNUT CREEK, CALIFORNIA
STORM DRAINAGE MODEL

***** TIME HISTORY OF H. G. L. *****

TIME	JUNCTION 7	JUNCTION 101	JUNCTION 102	JUNCTION GRND
0.0	GRND 7.50	GRND 7.50	GRND 8.00	
0.1	5.26	6.90	7.50	.00
0.2	5.73	6.90	7.50	.00
0.3	6.12	6.90	7.50	.00
0.4	6.51	6.90	7.50	.00
0.5	6.90	6.90	7.50	.00
0.6	6.31	6.90	7.50	.00
0.7	6.46	6.90	7.50	.00
0.8	7.36	6.90	7.50	.00
0.9	7.14	6.91	7.50	.00
1.0	7.11	6.91	7.50	.00
1.1	7.12	6.92	7.50	.00
1.2	7.13	6.93	7.50	.00
1.3	7.13	6.94	7.50	.00
1.4	7.13	6.95	7.50	.00
1.5	7.14	6.96	7.50	.00
1.6	7.15	6.97	7.50	.00
1.7	7.16	6.98	7.50	.00
1.8	7.17	6.99	7.50	.00
1.9	7.17	7.00	7.50	.00
2.0	7.17	7.00	7.50	.00
2.1	7.14	7.01	7.50	.00
2.2	7.12	7.02	7.50	.00
2.3	7.19	7.03	7.50	.00
2.4	7.08	7.04	7.50	.00
2.5	7.07	7.04	7.50	.00
2.6	7.07	7.05	7.50	.00
2.7	7.04	7.05	7.50	.00
2.8	7.04	7.05	7.50	.00
2.9	7.02	7.05	7.50	.00
3.0	7.00	7.05	7.50	.00
3.1	6.98	7.05	7.50	.00
3.2	6.94	7.04	7.50	.00
3.3	6.90	7.04	7.50	.00
3.4	6.85	7.04	7.50	.00
3.5	6.80	7.03	7.50	.00
3.6	6.74	7.03	7.50	.00
3.7	6.68	7.02	7.50	.00
3.8	6.66	7.02	7.50	.00
3.9	6.65	7.01	7.50	.00
4.0	6.62	7.00	7.50	.00
4.1	6.60	7.00	7.50	.00
4.2	6.58	6.99	7.50	.00
4.3	6.56	6.99	7.50	.00
4.4	6.53	6.98	7.50	.00
4.5	6.52	6.98	7.50	.00

TABLE III-32
(Continued)

TRANSPORT MODEL - SOUTH SEAFILL INITIAL PARK - RUN NO. 2
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

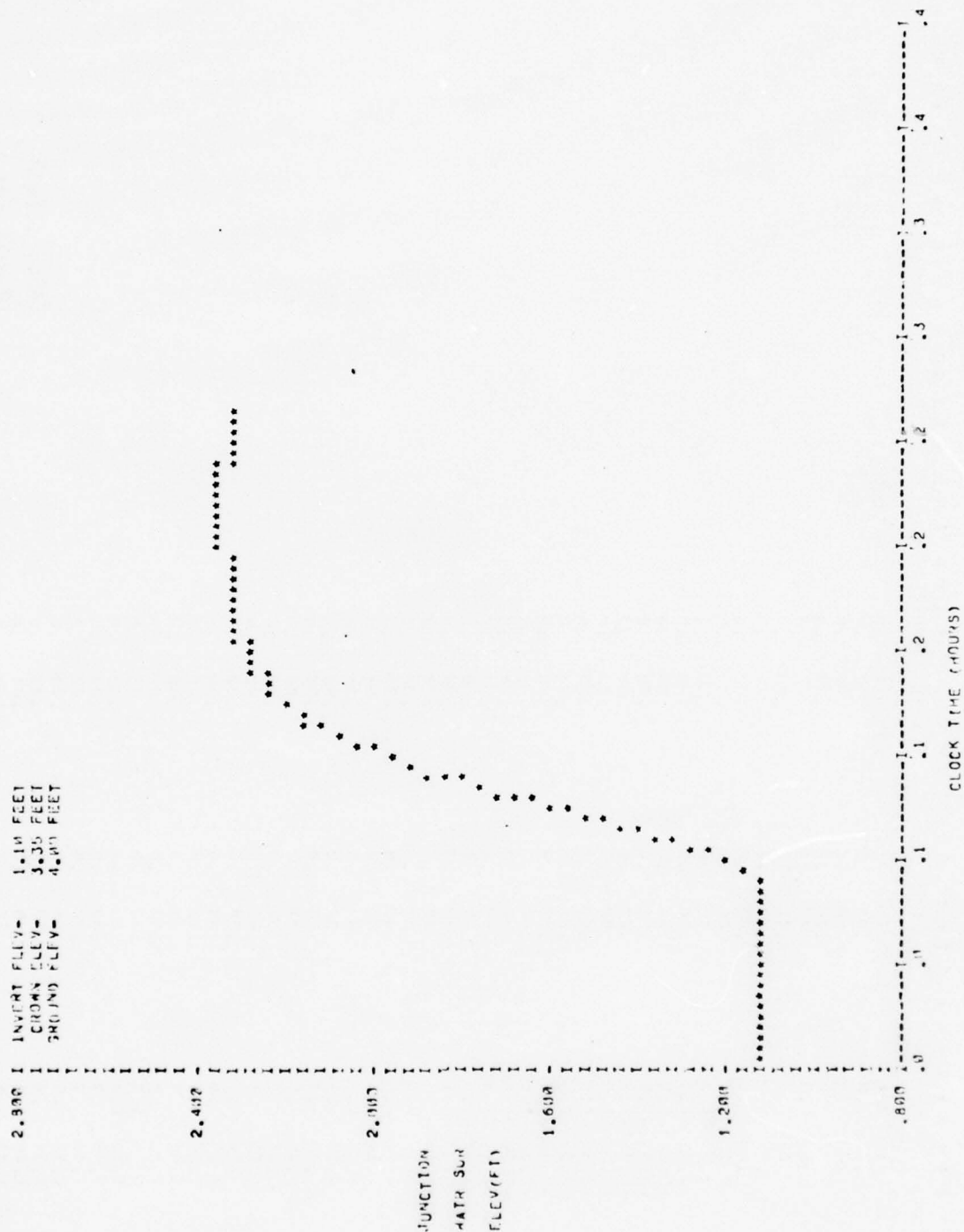
WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DRAINAGE MODEL

***** TIME HISTORY OF FLOW AND VELOCITY *****				
TIME	CONDUIT 301	CONDUIT 401	CONDUIT 402	CONDUIT
0.0	.00	.00	.00	.00
0.1	.00	.00	.00	.00
0.2	.00	.00	.00	.00
0.3	.00	.00	.00	.00
0.4	.00	.00	.00	.00
0.5	.00	.00	.00	.00
0.6	.00	.00	.00	.00
0.7	.00	.00	.00	.00
0.8	.00	.00	.00	.00
0.9	.00	.00	.00	.00
1.0	.00	.00	.00	.00
1.1	.00	.00	.00	.00
1.2	.00	.00	.00	.00
1.3	.00	.00	.00	.00
1.4	.00	.00	.00	.00
1.5	.00	.00	.00	.00
1.6	.00	.00	.00	.00
1.7	.00	.00	.00	.00
1.8	.00	.00	.00	.00
1.9	.00	.00	.00	.00
2.0	.00	.00	.00	.00
2.1	.00	.00	.00	.00
2.2	.00	.00	.00	.00
2.3	.00	.00	.00	.00
2.4	.00	.00	.00	.00
2.5	.00	.00	.00	.00
2.6	.00	.00	.00	.00
2.7	.00	.00	.00	.00
2.8	.00	.00	.00	.00
2.9	.00	.00	.00	.00
3.0	.00	.00	.00	.00
3.1	.00	.00	.00	.00
3.2	.00	.00	.00	.00
3.3	.00	.00	.00	.00
3.4	.00	.00	.00	.00
3.5	.00	.00	.00	.00
3.6	.00	.00	.00	.00
3.7	.00	.00	.00	.00
3.8	.00	.00	.00	.00
3.9	.00	.00	.00	.00
4.0	.00	.00	.00	.00
4.1	.00	.00	.00	.00
4.2	.00	.00	.00	.00
4.3	.00	.00	.00	.00
4.4	.00	.00	.00	.00
4.5	.00	.00	.00	.00
4.6	.00	.00	.00	.00
4.7	.00	.00	.00	.00
4.8	.00	.00	.00	.00
4.9	.00	.00	.00	.00
5.0	.00	.00	.00	.00
5.1	.00	.00	.00	.00
5.2	.00	.00	.00	.00
5.3	.00	.00	.00	.00
5.4	.00	.00	.00	.00
5.5	.00	.00	.00	.00
5.6	.00	.00	.00	.00
5.7	.00	.00	.00	.00
5.8	.00	.00	.00	.00
5.9	.00	.00	.00	.00
6.0	.00	.00	.00	.00
6.1	.00	.00	.00	.00
6.2	.00	.00	.00	.00
6.3	.00	.00	.00	.00
6.4	.00	.00	.00	.00
6.5	.00	.00	.00	.00
6.6	.00	.00	.00	.00
6.7	.00	.00	.00	.00
6.8	.00	.00	.00	.00
6.9	.00	.00	.00	.00
7.0	.00	.00	.00	.00
7.1	.00	.00	.00	.00
7.2	.00	.00	.00	.00
7.3	.00	.00	.00	.00
7.4	.00	.00	.00	.00
7.5	.00	.00	.00	.00
7.6	.00	.00	.00	.00
7.7	.00	.00	.00	.00
7.8	.00	.00	.00	.00
7.9	.00	.00	.00	.00
8.0	.00	.00	.00	.00
8.1	.00	.00	.00	.00
8.2	.00	.00	.00	.00
8.3	.00	.00	.00	.00
8.4	.00	.00	.00	.00
8.5	.00	.00	.00	.00
8.6	.00	.00	.00	.00
8.7	.00	.00	.00	.00
8.8	.00	.00	.00	.00
8.9	.00	.00	.00	.00
9.0	.00	.00	.00	.00
9.1	.00	.00	.00	.00
9.2	.00	.00	.00	.00
9.3	.00	.00	.00	.00
9.4	.00	.00	.00	.00
9.5	.00	.00	.00	.00
9.6	.00	.00	.00	.00
9.7	.00	.00	.00	.00
9.8	.00	.00	.00	.00
9.9	.00	.00	.00	.00
10.0	.00	.00	.00	.00

TABLE III-33
 (Continued)

TRANSPORT MODEL - SOUTH SALT LAKE INDUSTRIAL PARK - RUN NO. 2
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 WALNUT CREEK, CALIFORNIA
 STORM DATA AGE MODEL



JUNCTION NUMBER 19

FIGURE III-19 TIME HISTORY OF WATER SURFACE ELEVATION, FLOODING RUN 2

TRANSPORT MODEL - SOUTH BEATTLE INDUSTRIAL PARK - RUN NO. 2
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERING, INC.
 14150 CREEK ROAD, CALIFORNIA
 91000 DRAI - 1 MODEL

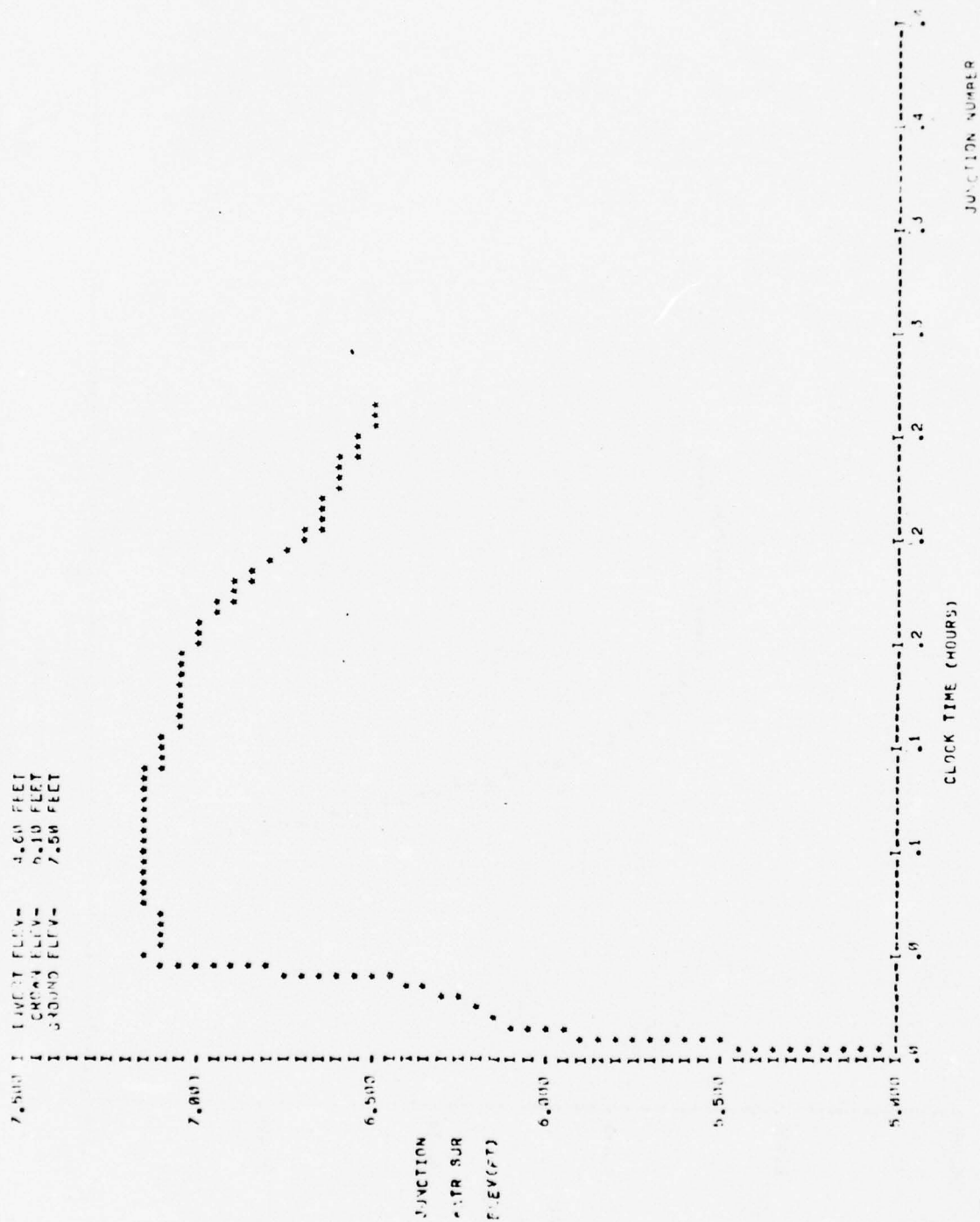


FIGURE III-20 TIME HISTORY OF WATER SURFACE ELEVATION FLOODING RUN 2

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 2
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

WATER RESOURCES ENGINEERS, INC.
 3400 CENTRAL EXP. CALIFORNIA
 STOCKTON, CALIF. 95210

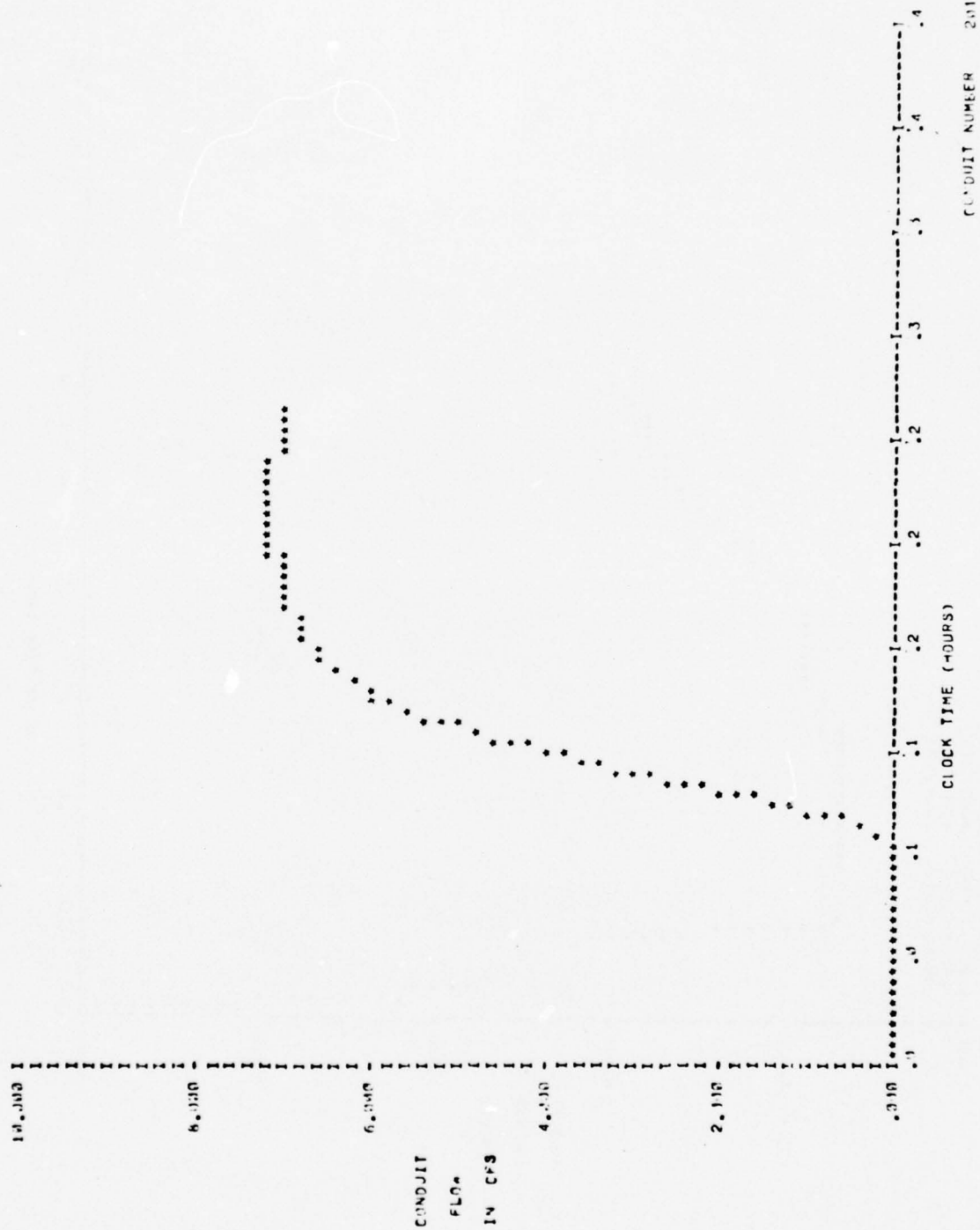


FIGURE III-21 TIME HISTORY OF CONDUIT FLOW, FLOODING RUN 2

WATER RESOURCES ENGINEERS, INC.
 PALM BEACH, CALIFORNIA
 STORM DRAINAGE MODEL

TRANSPORT MODEL - SOUTH SEATTLE INDUSTRIAL PARK - RUN NO. 2
 EXAMPLE PROBLEM FOR DEMONSTRATION OF SURFACE FLOODING

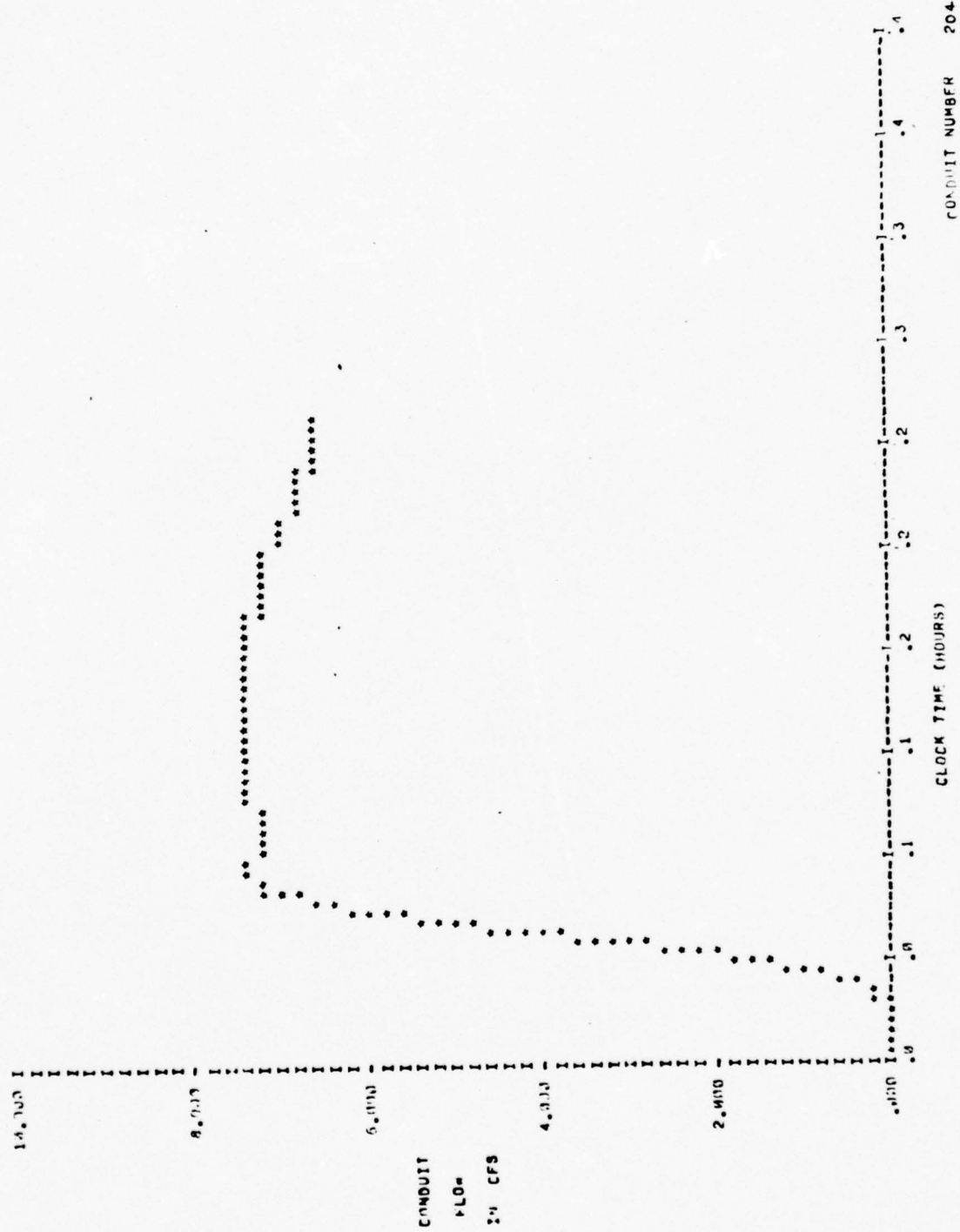


FIGURE III-22 TIME HISTORY OF CONDUIT FLOW, FLOODING RUN 2

CHAPTER IV

MODEL CALIBRATION PROCEDURE

INTRODUCTION

In order to fill the need for prototype data representative of the Seattle Metropolitan area, a program of data collection and model calibration was undertaken in connection with this project. The details and results of the data collection program, conducted by Metro, can be found in Metro's "Water Quality and Quantity Monitoring Program for the RIBCO Urban Runoff and Basin Drainage Study." It is the intent of this chapter to outline the procedure used in the model calibration process and to indicate the results of our calibration effort. The complete set of calibration computations are both tedious and voluminous and thus only examples of the calibration calculations are included in this chapter to give the reader an understanding of the procedures employed to develop the model coefficients for the Seattle Metropolitan area.

QUANTITY CALIBRATION

Model calibration is defined to be the process of determining local and appropriate values for the empirical coefficients which appear in the various models. It should be recognized that the calibration process itself is a somewhat empirical process, and that no quantifiable measure is made of how well the models have been calibrated. In the paragraphs which follow the adequacy of the calibration is judged by visual comparisons of model/prototype behavior and the point of "best" fit located by judgmental determination.

The calibration process was primarily concerned with the simulation of surface runoff. The calibration was performed using data on rainfall, runoff and runoff quality which was collected for seven calibration areas. The seven areas varied in size from 24 acres to over 600 acres. The areas represented four different land uses: 1) single family residential, 2) multi-family residential, 3) industrial, and 4) commercial. Computer simulation runs, attempting to duplicate the gaged hydrographs and pollutographs, were performed on the seven areas using a number of gaged rainfall events. Table IV-1 summarizes the areas used for calibration in this project.

Rainfall gages were installed in or near each of the seven calibration areas. The rainfall hyetographs from these gages were used directly in making calibration runs. When a rain gage was not located within a calibration area the hyetograph from the nearest rain gage representative of the gaged runoff hydrograph was used for the calibration runs. The rainfall hyetograph is the most important factor in determining the shape and magnitude of a simulated hydrograph.

The parameters selected for the representation of the subcatchment were carefully chosen to depict the runoff from the calibration area. The percent imperviousness of the subcatchment is a critical parameter for calibrating the quantity of runoff from a subcatchment. The other parameters of the subcatchment affect the runoff but none as importantly as the percent imperviousness.

Once the rainfall hyetographs and the subcatchment parameters were determined, simulation runs on the calibration areas were performed to best duplicate the gaged runoff hydrograph. Success in duplicating the gaged hydrographs with respect to total volume of runoff and the shape of the hydrograph was obtained for most areas but not for every rainfall event. The lack of accurate rainfall and runoff data for some areas made the quantity calibration of those areas more difficult to perform.

Calibration Area	Land Classification	Area in Acres
1. View Ridge 1	Single Family Residential	630
2. View Ridge 2	Multi-Family Residential	105
3. South Seattle Ind. Park	Industrial	27.5
4. Southcenter	Commercial	24
5. Lake Hills	Single Family Residential	139.9
6. Highland	Single Family Residential	107.4
7. Central Business District	Commercial	27.8

TABLE IV-1
CALIBRATION AREAS
SEATTLE METROPOLITAN AREA

The results of the runoff model calibration process indicate good representation of the various types of drainage basins associated with the seven calibration areas. Excellent results of simulating gaged hydrographs were obtained for both the largest calibration areas, View Ridge 1 and View Ridge 2 (735 acres total) and the smaller areas, Central Business District and South Seattle Industrial Park (25 acres each). Typical of the calibration results are the data shown in Figure IV-1. This figure shows the observed and modeled outflow hydrographs for the View Ridge 1 and Central Business District calibration areas for the storm of March 10, 1973. The agreement between model and prototype is judged satisfactory for these areas, with total runoff and general hydrography shape in reasonably close agreement for both areas. Of particular importance in obtaining a good simulation is an accurate rainfall hyetograph which represents the actual rainfall event that occurred over the calibration area. This was particularly evident for the 25-acre areas. A rain gage located even half a mile to a mile from an area does not necessarily represent that area's rainfall, especially the rainfall intensity. The calibration areas of Southcenter, Lake Hills, and Highlands had a limited amount of data that was suitable for the calibration process due to 1) the rain gage was not representative for the area, 2) the runoff hydrograph and the rainfall records did not correspond to each other, 3) the data was not available as a result of recorder malfunction. In every calibration area at least one good comparison between observed and simulated hydrographs was obtained with the exception of the Highlands area. The result of the calibration exercise is that the user can be confident that the Runoff model reasonably represents the runoff process for watersheds of varying sizes and land uses in the Seattle Metropolitan Area, assuming good rainfall data can be supplied as an input.

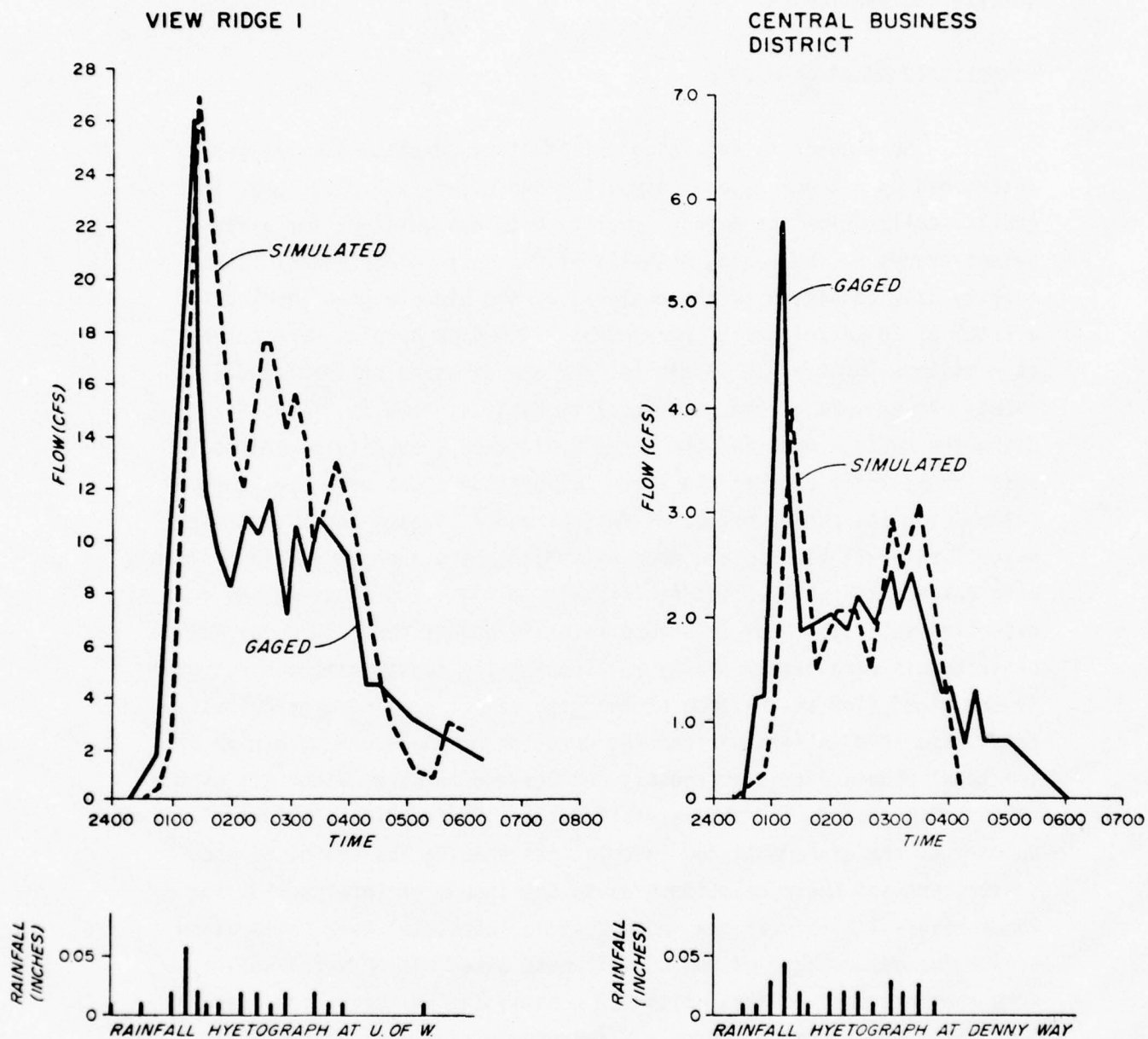


FIGURE IV-1 COMPARISON OF GAGED AND SIMULATED HYDROGRAPHS FOR THE STORM OF MARCH 10, 1973

QUALITY CALIBRATION

CONSTITUENT RELATIONSHIPS

Subsequent to obtaining satisfactory quantity simulations as determined by a comparison of simulated and observed hydrographs, the quality calibration was begun. Quality data was obtained for a few select storms at the gaging manholes of the calibration areas. The quality data consisted of the analysis of the manhole grab samples for a total of 28 water quality parameters. The grab samples were taken at a minimum interval of 15 minutes for the duration of the rainfall event. An example of the water quality data is shown in Table IV-2. Using the quality data and the gaged hydrographs, quality constituent relationships for each of the seven calibration areas were developed by determining the number of pounds in the runoff of each constituent for several rainfall events, and then determining the average relative amounts with respect to total solids (settleable solids + suspended solids + total dissolved solids). Mass emissions rates in pounds per second for all constituents were determined by multiplying the constituent concentration by the gaged flow at the time of the grab sampling. The mass emission rates were then integrated over the duration of the storm to arrive at the total poundage of each constituent assumed to have washed off of the calibration area during the rainfall event. Table IV-3 is an example summary of the aforementioned calculations showing the amount of each constituent and their relationships to the amount of total solids for three rainfall events at the South Seattle Industrial Park calibration area. The percentages of the constituents based on the total solids were then averaged to develop the 23 constituent relationships based on land use. Since there were only a few storms that were accurately monitored for complete quantity and quality data, judgment was used to eliminate obvious extreme values which would erroneously affect the average. These average values were then incorporated into the model as the variable QFACT and are the values that make the model specific to the Seattle area. The values of QFACT are shown in Table IV-4.

53 QUALITY DATA FOR SOUTH SEATTLE INDUSTRIAL PARK - STORY OF MARCH 16, 1973

UNITS IN MG/L OR WHATEVER									
SAMPLE	TIME	TEMP	DO	RHO	PH	CL	904	COND	HEX EXT
1	749.	9.5	11.1	1.8	7.8	2.1	2.0	56.0	17.0
2	829.	9.8	11.0	-0	7.7	1.5	-0	64.0	100.0
3	844.	8.5	12.1	7.4	7.7	2.7	-0	52.0	4.6
4	852.	9.3	11.4	22.0	7.7	4.5	6.8	81.0	7.4
5	914.	9.0	10.0	20.0	7.7	5.1	-0	110.0	8.7
6	929.	9.5	9.3	7.2	7.6	7.2	-0	152.0	2.8
7	944.	9.5	9.9	8.1	7.7	7.2	16.0	132.0	12.3
8	959.	9.6	10.4	2.6	7.6	6.9	-0	110.0	6.7
9	1014.	9.6	10.1	5.6	7.8	7.5	-0	86.0	14.0
10	1044.	10.0	10.5	5.6	7.8	7.5	-0	80.0	14.0
11	1059.	10.3	-0	1.8	7.6	6.1	15.0	84.0	6.7
12	1114.	9.3	-0	.5	7.7	3.0	-0	54.0	6.5
13	1123.	9.0	11.4	.5	7.8	2.1	-0	59.0	3.4
14	1244.	9.5	11.8	.0	7.8	2.1	-0	59.0	3.4

TURB 2.2
52.0
15.0
20.0
60.0
51.0
48.0
60.0
54.0
54.0
46.0
58.0
11.0
11.0

COD 10.0
153.0
21.0
32.0
62.0
69.0
75.0
67.0
61.0
61.0
51.0
46.0
20.0
20.0

UNITS IN MG/L									
SAMPLE	CJ	PH	FE	HG	CR	CD	AS	ZN	SET-S
1	.01330	.10333	1.40000	.00020	.01000	.00400	-0.00000	.15200	3.9
2	.05330	.10000	.22000	.00020	.01000	.00400	-0.00000	.12000	59.0
3	.02330	.10000	4.90000	.00020	.01000	.00400	-0.00000	.04500	13.0
4	.03000	.12000	.64000	.00020	.01000	.00900	-0.00000	.12000	32.0
5	.04000	.20000	2.50000	.00020	.01330	.00400	-0.00000	.28000	30.0
6	.06000	.37000	3.20000	.00020	.01330	.00400	-0.00000	.52000	60.0
7	.07000	.45000	3.00000	.00020	.01000	.00400	-0.00000	.49000	71.0
8	.07000	.40000	4.70000	.00020	.01000	.00400	-0.00000	.40000	40.0
9	.07000	.37000	3.10000	.00020	.01000	.00400	-0.00000	.36000	34.0
10	.07000	.37000	3.10000	.00020	.01000	.00400	-0.00000	.36000	34.0
11	.07000	.22000	2.30000	.00020	.01000	.00900	-0.00000	.38000	58.0
12	.04300	.10000	5.10000	.00020	.01000	.00400	-0.00000	.13000	100.0
13	.02000	.10000	.70000	.00020	.01000	.00400	-0.00000	.15000	.1
14	.02000	.13000	.70000	.00020	.01000	.00400	-0.00000	.15000	.1

SUS-S 24.0
112.0
4.0
48.0
72.0
76.0
64.0
200.0
110.0
110.0
88.0
100.0
24.0
24.0

YDS 92.0
113.0
88.0
100.0
120.0
140.0
220.0
210.0
190.0
190.0
180.0
200.0
180.0
180.0

UNITS IN MG/L, ORG/100 ML AND CFS									
SAMPLE	KJELD	NH3	NO2	NO3	TOT HYD P	ORTHO	TOT COL	FECAL COL	FLOW
1	.29	.04	.01	.05	.25	.00	5.	2.	.010
2	.43	.03	.01	.10	.27	.00	4.	2.	.080
3	.29	.02	.01	.10	.06	.03	4.	2.	.040
4	.42	.04	.06	.20	.15	.02	360.	19.	.060
5	.46	.33	.08	.40	.18	.06	340.	19.	.280
6	1.10	.22	.10	.50	.21	.06	240.	9.	.140
7	1.50	.30	.12	.50	.24	.06	520.	13.	.270
8	1.30	.28	.11	.35	.32	.10	1400.	87.	.230
9	.90	.23	.09	.30	.21	.07	3000.	50.	.100
10	.90	.20	.09	.30	.21	.07	3000.	50.	.100
11	1.20	.28	.07	.25	.19	.06	1100.	12.	.220
12	.71	.12	.03	.10	.19	.02	40.	2.	.140
13	.59	.20	.02	.15	.07	.00	1500.	2.	.100
14	.59	.20	.02	.15	.07	.00	1500.	2.	.100

TABLE IV-2 EXAMPLE OF MONITORED WATER QUALITY DATA

Constituents	Storm of March 10		Storm of March 16		Storm of June 6	
	Pounds	% Tot. Sol.	Pounds	% Tot. Sol.	Pounds	% Tot. Sol.
DO	16.78	3.444	1.212	3.231	1.77	2.168
BOD	6.528	1.340	.5493	1.464	9.653	11.82
Cl	0.5645	0.1159	.615	1.639	7.851	9.615
SO ₄	10.99	2.255	1.515	4.038	8.507	10.42
Hex. Ext.	12.44	2.553	1.688	4.501	2.912	3.566
COO	49.68	10.20	6.747	17.99	3x5.81	43.86
Cu	0.07813	0.01604	.006017	.01604	.02028	.02483
Pb	0.1608	0.03301	.03047	.08124	.0328	.04016
Fe	0.6747	0.1385	.3005	.8011	.2349	.2877
H ₂ O	0.0004555	0.00009555	.00002421	.00006455	.0001243	.0001522
Cr	0.01490	0.003059	.001211	.003227	.002674	.003274
Cd	0.006792	0.001394	.0006388	.001703	.001274	.00156
As	---	---	---	---	.014	.01714
Zn	0.2303	0.04727	.03529	.09406	.1250	.153
Set. Sol.	66.68	13.69	5.858	x15.62	19.17	x23.48
Sus. Sol.	95.41	19.58	10.32	x27.51	22.53	x27.59
TDS	325.1	66.73	21.34	x56.88	39.96	x48.93
Kjeld.	1.005	0.2063	.1054	.2809	.4421	.5414
NH ₃	0.1898	0.03896	.02747	.07323	.05777	.07075
NO ₂	0.03819	0.007839	.00737	.02063	.01508	.01846
NO ₃	0.5024	0.1031	.03259	.08687	.2220	.2719
Tot. Hyd. P.	0.2873	0.05897	.02193	.05847	.07375	.09032
Ortho	0.03555	0.007297	.004991	.0133	.02667	.03266
Tot. Coll.	8.164+9	1.676+7//	6.708+8	1.788+7	3.684+9	4.511+7
Fecal Coli.	4.790+9	9.832+6//	1.07+7	2.852+5	2.792+7	3.419+5
Total Sol.	487.2		37.51		81.66	

TABLE IV-3
STORMWATER QUALITY CONSTITUENT AMOUNTS FOR THE
SOUTH SEATTLE INDUSTRIAL PARK CALIBRATION AREA

Constituents	Land Use Classification				
	Single Family	Multi-Family	Commercial	Industrial	Undeveloped and Parks
Set Solids	180	280	240	176	153
Sus Solids	340	250	445	249	323
TDS	480	470	315	575	525
BOD	35.7	53.1	35.9	14.0	11.0
COD	338	427	300	240	222
Chlorides	26.3	29.8	22.2	37.9	54.7
SO ₄	31.7	48.4	49.8	55.7	92.2
Grease	45.1	78.6	30.2	35.4	28.0
Tot Coliform	7.1×10^5	2.9×10^6	2.9×10^4	6.0×10^4	6.2×10^4
Fecal Coliform	8.2×10^4	1.9×10^5	8.2×10^2	7.7×10^3	2.0×10^4
NH ₃	0.66	2.89	0.93	0.61	0.37
Org. Nit.	5.00	0.61	4.05	2.82	4.13
NO ₃ + NO ₂	2.51	4.51	2.27	1.70	7.29
Total Hyd P	1.06	1.08	0.65	0.69	1.19
Ortho PO ₄	0.25	0.47	0.19	0.18	0.36
Hg	0.0053	0.0030	0.0012	0.0009	0.0019
Cu	0.29	0.17	0.21	0.19	0.78
Zn	0.40	0.33	0.78	0.98	0.26
Pb	1.21	1.57	1.07	0.51	0.68
Cr	0.056	0.052	0.069	0.032	0.061
Cd	0.025	0.022	0.015	0.015	0.030
As	0.178	0.139	0.117	0.171	---

¹Loadings in mg/gram of Total Solids or organisms/gram for Coliform.

TABLE IV-4
STORMWATER QUALITY CONSTITUENTS RELATIONSHIPS¹

POLLUTANT BUILDUP

The rate of pollutant buildup on the calibration areas was not measured in the calibration process and must be considered an unknown at present. The model uses a straight line accumulation of dust and dirt (assumed equivalent to total solids in runoff) based on a variable amount of pounds in dust and dirt per day per 100 feet of curb, depending on the type of land use. The original EPA Storm Water Model used pollutant loading rates determined in a separate study in the Chicago area. These rates did not seem applicable for the Seattle area in light of data obtained from additional studies recently performed in the local area. Based on the EPA report titled, "Water Pollution Aspects of Street Surface Contaminants," dated November 1972, an average loading factor of 0.72 pounds per day per 100 feet of curb was adopted. This rate of 0.72 is less than one half of the average loading used in the original model. The loading rates for the five land use classifications were then determined based on the original model rates and the average Seattle loading rate as shown in Table IV-5.

Land Use Classification	EPA Stormwater Model Loading Rate	RIBCO Loading Rate
Overall	1.5	0.72
Single Family Residential	0.7	0.4
Multi-Family Residential	2.3	1.1
Commercial	3.3	1.6
Industrial	4.6	2.2
Undeveloped or park land	1.5	0.7

1. Loading rates in units of pounds per day per 100 feet of curb

TABLE IV-5
POLLUTANT LOADING RATES
SEATTLE METROPOLITAN AREA

The loading rates were then incorporated into the Runoff Block as DDFACT. Quality simulation runs were performed for the calibration areas. Lack of accurate and consistent data for rainfall, runoff, and quality for the few select storms made the quality calibration extremely difficult for most areas.

The amount of buildup of dust and dirt is dependent on the number of dry days preceding the rainfall event to be analyzed and the frequency of street sweeping activities. For the quality calibration process, street sweeping schedule information for three of the calibration areas was obtained from City of Seattle, Department of Engineering. The frequency of street sweeping varied from areas being swept once a day to areas not being swept on a regular basis. The number of dry days preceding a rainfall event was determined by inspection of rainfall data. The guideline presented in the original Stormwater Management Model work which stated that nearly all the pollutant is washed off the drainage basin with a rainfall intensity of 0.5 inches per hour for a duration of one hour was loosely used in the calibration process to estimate the number of dry days preceding monitored rainfall events. The monitoring program spanned one of the driest springs and summers on record and therefore considerable judgment was relied upon to arrive at the number of dry days preceding a storm. A value of 6 dry days was used for the March 16, 1973, storm.

The hydrographs and pollutographs generated from the Runoff model are used as input to the Transport model and Transport Quality model. The values for the runoff quantity and quality are determined by the Runoff model simulation and the other two models have only a slight effect on altering either except for the attenuation of flow due to backwater effects which can be modeled by the Transport model.

At the present time it is not possible to make a quantitative statement concerning the absolute accuracy of the quality simulation

and its various component parameters. In many cases the quality simulation seems reasonably good but in other cases the results may deviate by factors of two or more from observed values. It is probably safe to assume that the models are reasonably adequate for assessing the quality differences between various drainage alternatives, but that more data needs to be collected on the rate of pollutant buildup on and washoff from the individual watersheds before the accuracy of surface quality model will rival that of surface quantity model.

CHAPTER V

ADDITIONAL MODEL DETAILS

MATHEMATICAL RELATIONSHIPS

The following sections give the mathematical basis of the three major sections of the urban stormwater model, the Runoff Block, the Transport Block, and the Transport Quality Block. Details of the numerical discretization, underlying assumptions and input requirements are also described.

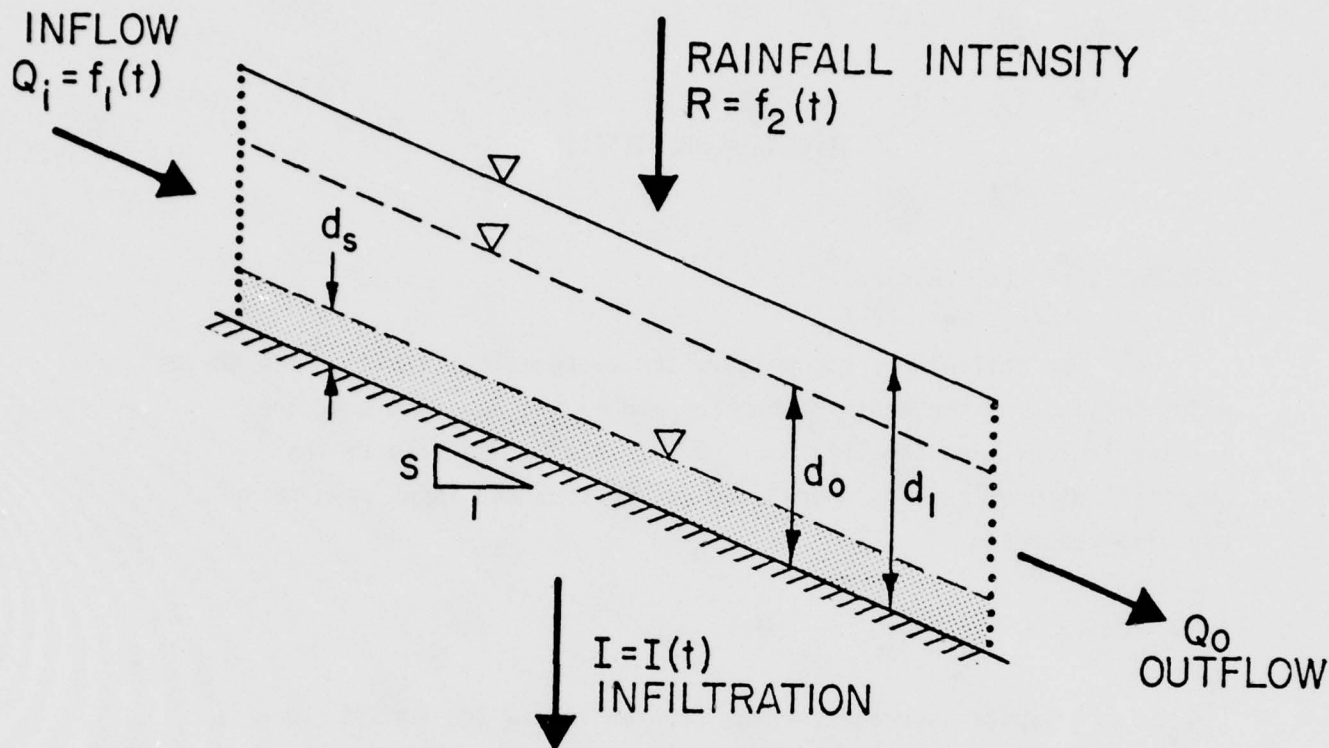
RUNOFF BLOCK

A typical subwatershed as represented in the Runoff Block is shown in Figure V-1. It is assumed that conditions of gradually varied, uniform flow obtain on the watershed, and that flow computations can be made based on kinematic wave theory. Three flow depths are shown on the figure:

- d_0 = depth at time t ,
- d_1 = depth at time $t+\Delta t$, and
- d_s = maximum depth of detention storage.

The objective of the calculations which pertain to this element is to find the new depth, d_1 , determining, in the process, the outflow, Q_0 , and maintaining mass continuity at all times. To accomplish this, two equations must be solved simultaneously. First, the continuity or storage equation

$$\frac{\Delta d}{\Delta t} = \frac{d_1 - d_0}{\Delta t} = R - I + \frac{Q_i - Q_0}{A_s} \quad (V-1)$$



INFILTRATION:

$$I = k_1 + (k_2 - k_1) e^{-k_3 t}$$

FLOW:

$$Q_o = \frac{1.49}{n} S^{1/2} W \left(\frac{d_o + d_l}{2} - d_s \right)^{5/3}$$

STORAGE:

$$\frac{\Delta d}{\Delta t} = \left[R - I + \frac{Q_i - Q_o}{A_s} \right]$$

FIGURE V-1 ELEMENTARY FLOW CALCULATIONS TYPICAL ELEMENT

where

- R = rainfall during Δt ,
- I = infiltration to groundwater during Δt ,
- Q_i = inflow from upstream catchments,
- Q_o = outflow from catchment,
- A_s = surface area of element,

and second, the flow equation, which is a form of Manning's equation

$$Q_o = \frac{1.49}{n} s^{1/2} w \left(\frac{d_o + d_i}{2} \right) - d_s^{5/3} \quad (V-2)$$

where

- n = Manning coefficient
- w = width of the plane

Here we have two equations in two unknowns, Q_o and d_i . Note that the flow computation is based on the average depth during Δt , and that surface detention is not included in the effective depth of flow.

Rainfall intensity is an input quantity, variable in time, but considered constant during each time interval Δt .

Infiltration is computed by a modified Horton formula

$$I = K_1 + (K_2 - K_1) e^{-K_3 t} \quad (V-3)$$

where

- K_1, K_2 = minimum and maximum infiltration rates, respectively, and
- K_3 = exponential rate of loss in infiltration capacity.

During periods of light or zero rainfall, the net precipitation value, $R-I$, could become negative. Traps in the program prevent this occurrence, thus modifying the Horton approach somewhat.

The simultaneous solution of Equations V-1 and V-2 is performed by a Newton's method, which easily handles the nonlinearity involved. First the equations are combined and rearranged in the form

$$F = 0 = \Delta d - \Delta t (k \bar{d}^{5/3} + R_{\text{net}}) \quad (\text{V-4})$$

where

F = Newton's function

$$k = - \left(\frac{1.49}{n} s^{1/2} w \right) / A_s,$$

$$\bar{d} = \frac{d_0 + d_1}{2} - d_s = d_0 - d_s + \frac{\Delta d}{2}, \text{ and}$$

$$R_{\text{net}} = (R - I) + (Q_i)/A_s$$

Then, differentiating yields

$$\frac{dF}{d(\Delta d)} = 1 - \Delta t \frac{5}{6} k \bar{d}^{2/3} \quad (\text{V-5})$$

The numerical method is a recursive process for finding the value of Δd ,

$$(\Delta d)_{n+1} = (\Delta d)_n - \frac{F_n}{\left(\frac{dF_n}{d(\Delta d)} \right)} \quad (\text{V-6})$$

where the subscripts refer to the n^{th} and $(n+1)^{\text{th}}$ iterations. Repeated application of this expression converges upon $F = 0$, which is the desired results.

Catch basins collect and store pollutants during dry weather, flushing rather rapidly in the early hours of a storm. Analysis of their behavior is mostly empirical, and field data should be obtained whenever possible. The program computes the washout of material from catch basins by the expression

$$M_c = \frac{\bar{M}_c}{\Delta t} \left(1 - e^{-\frac{Q_c t}{1.6 \bar{V}_c}} \right) \quad (\text{V-7})$$

where

- M_C = mass emission rate from catch basins (mass/unit time),
- \bar{M}_C = total mass in catch basins at beginning of time interval,
- Q_C = flow through catch basins (runoff from pervious and impervious areas),
- \bar{V}_C = total catch basin volume.

The total available mass, \bar{M}_C , includes that remaining from the original contents at the start of the storm event, plus material washed into the catch basins during the storm by the surface runoff.

Surface runoff of pollutants is treated much the same as catch basin washout. The buildup of material on the surface is based upon data contained in the study by the American Public Works Association, January 1969, entitled, "Water Pollution Aspects of Urban Runoff." In this study

$$P_O = f(K, D, G, N) \quad (V-8)$$

where

- P_O = total mass on watershed at start of storm,
- K = mass of constituent per unit mass of dust and dirt (a function of land use)
- D = rate of dust and dirt accumulation (also a function of land use)
- G = total length of gutters in the area,
- N = number of days since last storm or street cleaning.

Auxiliary computations account for the efficiency of the street cleaning process and other minor variations.

Once the mass of the pollutant, P , on the watershed has been determined the rate of washoff to the local drainage course (gutter) can be expressed by a first order rate equation as

$$\frac{dP}{dt} = kP \quad (V-9)$$

where

k = runoff coefficient

P = the mass of pollutant on the subwatershed

Now, if we assume that the runoff coefficient varies directly with the rate of surface runoff we can write

$$K = br \quad (V-10)$$

where

b = proportionality coefficient

r = rate of surface runoff

To evaluate b we shall assume that a uniform runoff of 0.5 in/hour would wash away 90 percent of the pollutant in one hour. This yields a value of $b = 4.6$ and Equation V-9 takes the form

$$\frac{dP}{dt} = 4.6 rt \quad (V-11)$$

Further, on the watershed itself the time history of the pollutant is given by the simple exponential decay as

$$P = P_0 e^{-4.6 rt} \quad (V-12)$$

To route a typical pollutant through the surface drainage system we can write a mass balance for each gutter as

$$\frac{dM}{dt} = \sum_{i=1}^n s_i \quad (V-13)$$

where

M = the total mass in the gutter volume

s_i = a flux of mass in or out of the control volume

n = the number of mass fluxes associated with the gutter. This will usually be upstream gutter inflow and tributary watershed washoff

If we further define

$$M = V C \quad (V-14)$$

where

V = the volume of the gutter

C = the concentration of pollutant

and

$$\frac{dM}{dt} = \frac{d(VC)}{dt} = C \frac{dV}{dt} + V \frac{dC}{dt} \quad (V-15)$$

or

$$V \frac{dC}{dt} = \sum s_i - C \frac{dV}{dt} \quad (V-16)$$

For simplicity let $dc/dt = \dot{C}$ and $dV/dt = \dot{V}$ and Equation V-16 becomes

$$V\dot{C} = \sum_{i=1}^n s_i - C \dot{V} \quad (V-17)$$

To achieve an integration of Equation V-17 with respect to time we shall make the following assumption concerning the behavior of concentration in time.

$$C_{t+\Delta t} = C_t + \frac{\Delta t}{2} (\dot{C}_t + \dot{C}_{t+\Delta t}) \quad (V-18)$$

where

$C_t, C_{t+\Delta t}$ = pollutant concentration at a time, t ,
and at a later time $t+\Delta t$

$\dot{C}_t, \dot{C}_{t+\Delta t}$ = the rate of change of concentration at
times t and $t+\Delta t$, respectively

Solving Equation V-18 for $\dot{C}_{t+\Delta t}$ we obtain

$$\dot{C}_{t+\Delta t} = \frac{2}{\Delta t} C_{t+\Delta t} - \left(\frac{2}{\Delta t} C_t + \dot{C}_t \right) \quad (V-19)$$

In the general case C_t and \dot{C}_t are known from a previous solution or initial conditions and can be treated as constants for any time step. Accordingly we shall define

$$\beta = \frac{2}{\Delta t} C_t + \dot{C}_t \quad (V-20)$$

$$\alpha = \frac{2}{\Delta t} \quad (V-21)$$

which substituted in Equation V-19 gives

$$\dot{C}_{t+\Delta t} = \alpha C_{t+\Delta t} - \beta \quad (V-22)$$

As Equations V-17 and V-22 are general in nature and refer to conditions at a particular instant in time, they can be combined as follows

$$C\dot{V} + V(\alpha C - \beta) = \sum_{i=1}^n s_i$$

or

$$C\dot{V} + C\alpha V - \beta V = \sum_{i=1}^n s_i \quad (V-23)$$

Usually the term $\sum_{i=1}^n s_i$ contains several mass inflows, and one mass outflow, QC, from the gutter. This being the case Equation V-23 is finally written as

$$C\dot{V} + C\alpha V - \beta V = \sum_{i=1}^n s_i - QC \quad (V-24)$$

which can be solved for the concentration at the end of the time step Δt in the form

$$C = \frac{\sum_{i=1}^n s_i + \beta V}{V + \alpha V + Q} \quad (V-25)$$

Equation V-25 is the form used in the quality routing of the Runoff Block, and is solved sequentially for each gutter moving down the tree-shaped structure required by the model. The outflow from each gutter becomes the inflow to the next, and total mass flux is summed using gutter, watershed and catch basin contributions.

TRANSPORT BLOCK

The Transport Block uses a *link-node* description of a sewer system which lends itself very nicely to the discrete representation of the physical system and to its mathematical solution. The conduit system is idealized as a series of *links* (pipes) which are connected to each other at *nodes*. Links and nodes each have very precisely defined qualities which, taken together, represent the entire pipe network. Moreover, the link-node approach is very useful in representing the various flow control devices.

Links transmit flow from point to point. Properties associated with the links are roughness, length, cross-sectional area, hydraulic radius and surface width. The last three properties are functions of the instantaneous depth of flow. Any shape cross-section can be incorporated easily into the computer program; at present it will accept pipes which are rectangular, circular, horseshoe, baskethandle or eggshape. A trapezoidal open channel is also permitted.

The primary dependent variable in the links is the discharge, Q . It is assumed that Q is constant (in space, not time) in the link. This is a common assumption in the link-node method. It should be noted that the velocity and the cross-sectional area of flow, or depth, are not constant in the link.

Nodes are the storage elements of the system. The variables associated with a node are volume, head, surface area and inflow/outflow. The primary dependent variable is the head, H , which is assumed to be constant (in space, not time), except for some special cases as noted below.

A sketch of the link-node idealization is shown in Figure V-2. A node resembles a manhole, i.e., it is located at a point and has a head associated with it. Inflow and outflow occur at a node. However, the

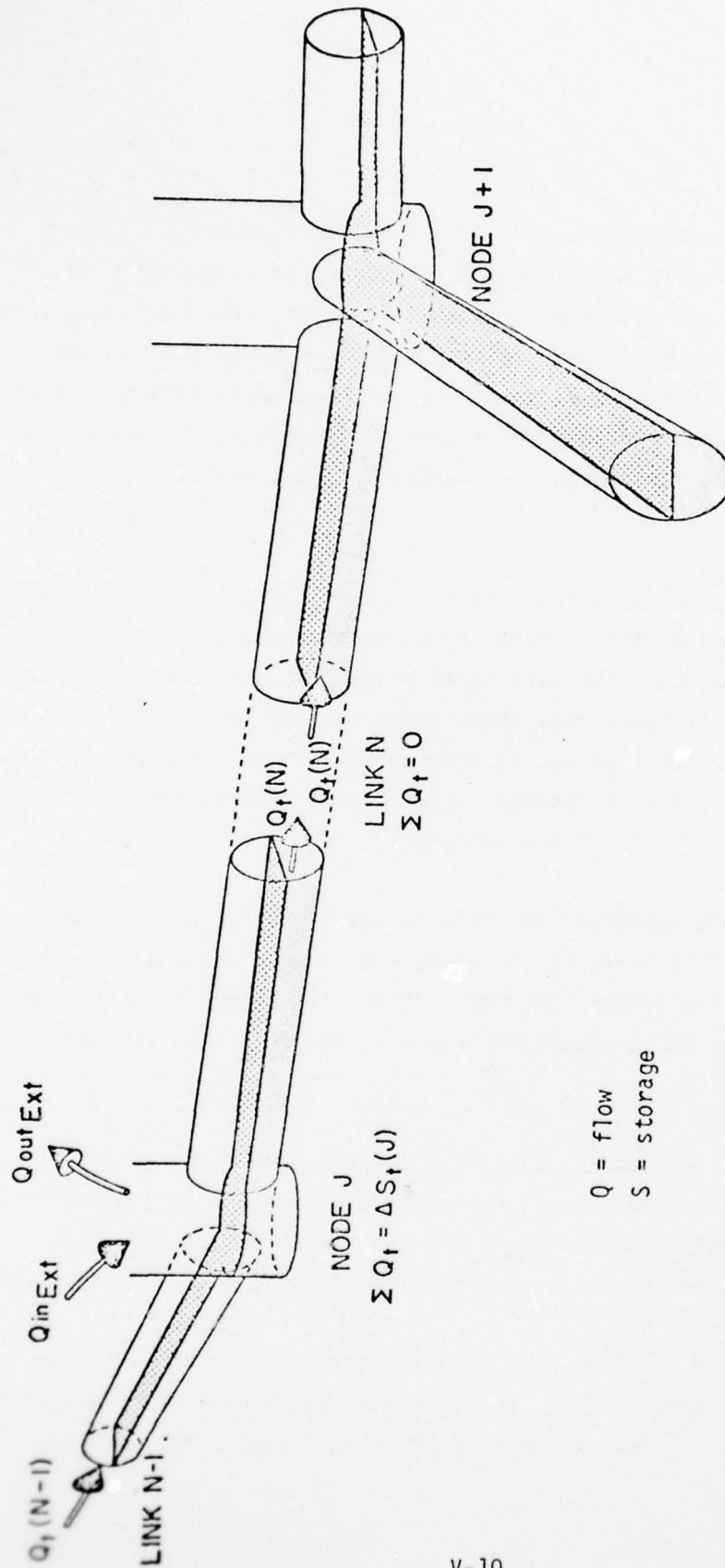


FIGURE V-2 CONCEPTUAL REPRESENTATION OF THE WRE TRANSPORT MODEL

volume of the node is roughly equivalent to the water volume in the half pipe lengths which enter the node. The link, as shown in the figure, is the flow path transferring fluid from one node to the next.

This conceptual representation of a sewer system, which is physically as well as mathematically descriptive, proves to be very useful. Dynamic flow in sewers is an extremely complicated process, with many subtleties surrounding the actual numerical solution. The development of the model showed that a thorough understanding of both the physical and mathematical aspects is essential to produce a working model.

The basic differential equations for the sewer flow problem are the equations of motion and continuity. The general motion equation for discharge in a conduit not flowing full is

$$\frac{\partial Q}{\partial t} = -gAS_f + 2u \frac{\partial A}{\partial t} + u^2 \frac{\partial A}{\partial x} - gA \frac{\partial H}{\partial x} \quad (V-26)$$

where

Q = discharge,

u = velocity,

A = cross-sectional area of the flow,

H = hydraulic head,

S_f = friction slope,

x = distance along conduit, and

t = time.

The friction slope can be expressed as

$$S_f = \frac{k}{gAR^{4/3}} Q|u| \quad (V-27)$$

where

$$k = g \left(\frac{n}{1.49} \right)^2,$$

n = Manning's roughness coefficient, and
 R = hydraulic radius.

The absolute value sign ensures that the frictional force always opposes the flow.

There are a number of ways to express the motion equation in finite form. This program uses the expression

$$\left(\frac{\partial Q}{\partial t} \right)_t = \frac{1}{1 + \frac{k}{\bar{R}_t^{4/3}} |\bar{u}_t| \Delta t} \left[- \frac{k}{\bar{R}_t^{4/3}} |\bar{u}_t| Q_t + 2\bar{u}_t \frac{\bar{A}_t - \bar{A}_{t-\Delta t}}{\Delta t} + \bar{u}_t^2 \frac{A_j - A_i}{L} - g\bar{A}_t \left(\frac{(H_j - C_1 \frac{u_j^2}{2g}) - (H_i + C_2 \frac{u_i^2}{2g})}{L} \right) \right] \quad (V-28)$$

to evaluate the derivative of Q at any time t . The term $C \frac{u^2}{2g}$ is the entrance and exit losses in the conduit. The coefficients C_1 and C_2 are input values. The subscripts i, j , refer to the nodal values at the ends of the link. The barred symbols for R, u and A indicate a weighted average along the link, e.g.,

$$\bar{R}_t = \frac{1}{4} (R_i + 2 R_m + R_j)_t \quad (V-29)$$

where the subscript m refers to the midpoint of the link.

The continuity equation for a node can be written directly in finite form. It is, for time t ,

$$\left(\frac{\partial H}{\partial t} \right)_t = \frac{\Sigma Q_t}{A_{st}} \quad (V-30)$$

where

- ΣQ_t = algebraic sum of all conduit flows and I/O flows to the node,
- A_{st} = water surface area associated with the node.

When all of the pipes entering a node are flowing full, the node is said to be surcharged. The usual form of the continuity equation is not strictly applicable in this case, because no additional storage is available at the node. Continuity then becomes:

$$\Sigma Q_t = 0 \quad (V-31)$$

and the earlier form is indeterminate. The exact change in hydraulic head cannot be determined directly; the situation is now a dynamic version of the traditional pipe network problem. However, an approximate, first order correction based on the Hardy Cross method can be computed. The Hardy Cross head correction for a node is

$$\Delta h = \frac{-n \Sigma Q}{\Sigma \left(\frac{Q}{H} \right)} \quad (V-32)$$

where

- Δh = change in nodal head for one iteration,
- Q = flow in a line entering the node,
- H = pressure drop along that line, and
- Σ = summation over all lines entering node.

Successive application of Equation V-32 to the nodes of the pipe network leads to the satisfaction of Equation V-31. A derivation similar to that used to obtain Equation V-32, but using the dynamic equation of motion V-28 yields

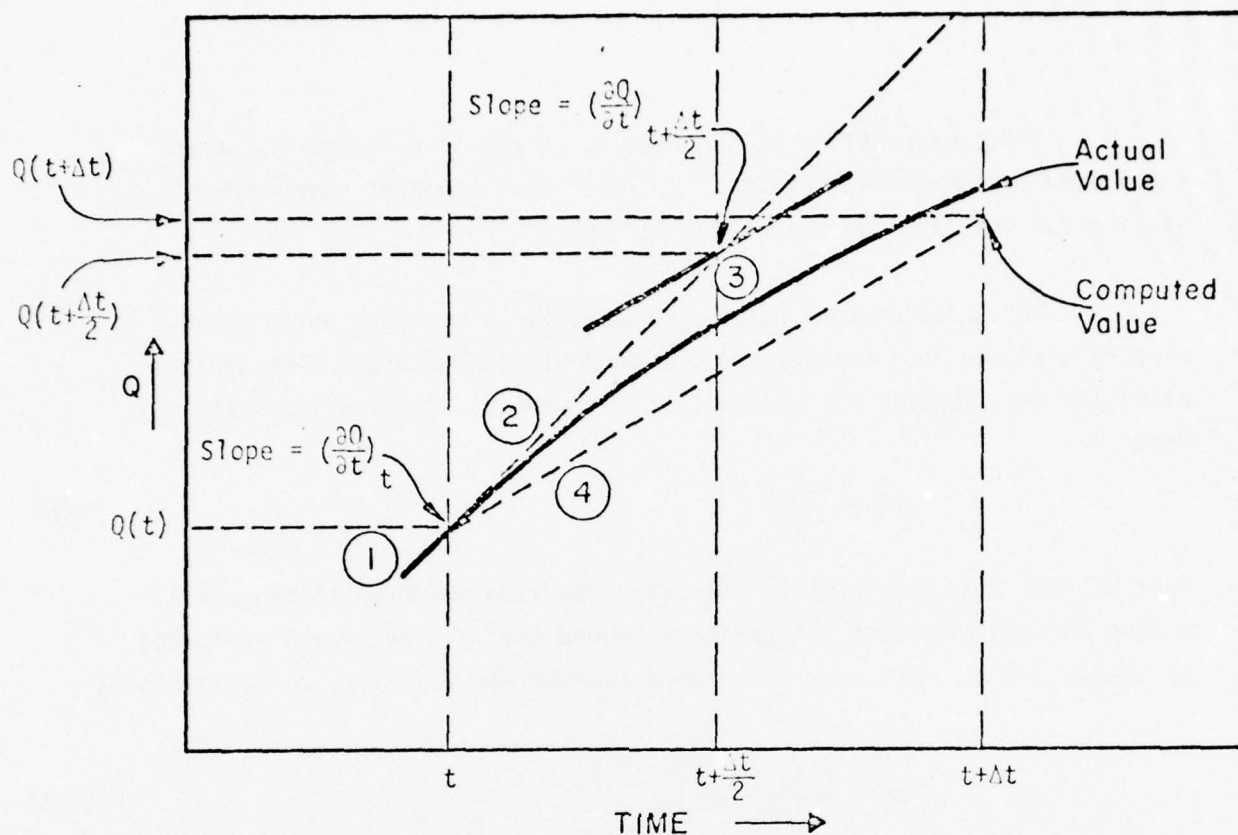
$$\left(\frac{\partial H}{\partial t} \right)_t = K \frac{\Sigma Q_t}{g(\Delta t)^2 \Sigma \frac{A}{L}} \quad (V-33)$$

where K = Constant, usually taken as 0.25 to introduce some underrelaxation in the system. Note that A is the cross-sectional area of the lines; the term $\frac{k}{g(\Delta t)^2 \sum L}$ is a measure of the capacity of the system to absorb excess flow. It is a kind of equivalent surface area. For a surcharged node, the calculations are carried out using Equation V-33, which is identical in form to Equation V-30. The process could be an iterative one, but for small time steps, where ΔH remains small, the first order approximation has been found to work sufficiently well.

Flooding is a special case of surcharge, when the hydraulic grade line breaks the ground surface. Traps in the program limit the hydraulic grade line to a value no greater than the ground elevation.

The numerical integration of equations can be accomplished by a modified Euler method. The results are accurate and, when certain constraints are recognized, stable. Figure V-3 shows how the process would work if only one equation were involved. The first three operations determine the slope at the "half-step" time. This is used in operation ④ to project the "full-step". In other words, it is assumed that the slope at time $t + \frac{\Delta t}{2}$ is the mean slope during the interval. The method is extended easily to more than one equation, although graphic representation is then very difficult.

The modified Euler method yields a completely explicit approach. The motion equation is applied to each link and the continuity equation to each node, entirely without implicit coupling. It is well known that explicit methods involve fairly simple arithmetic and require little storage space, compared to implicit methods. However, they are generally less stable, and often require very short time steps.



- ① Compute $(\frac{\partial Q}{\partial t})_t$ from properties of system at time t
- ② Project $Q(t + \frac{\Delta t}{2})$ as $Q(t + \frac{\Delta t}{2}) = Q(t) + (\frac{\partial Q}{\partial t})_t \frac{\Delta t}{2}$
- ③ a. Compute system properties at $t + \frac{\Delta t}{2}$
b. Form $(\frac{\partial Q}{\partial t})_{t + \frac{\Delta t}{2}}$ from properties of system at time $t + \frac{\Delta t}{2}$
- ④ Project $Q(t + \Delta t)$ as $Q(t + \Delta t) = Q(t + \frac{\Delta t}{2}) + (\frac{\partial Q}{\partial t})_{t + \frac{\Delta t}{2}} \frac{\Delta t}{2}$

FIGURE V-3 "HALF-STEP FULL-STEP" PROJECTION TECHNIQUE
FOR DISCHARGE COMPUTATION

First examination of the results seemed to validate the usual requirements of explicit methods. A closer look revealed some rather distinctive features which are worth noting.

The solution does become unstable for time steps which exceed certain criteria, but not for reasons commonly encountered. The typical stability relationship for solutions of the motion equation is of the form

$$\Delta t \leq \frac{L}{\sqrt{gy}} \quad (V-34)$$

that is, the time step must be less than the time required to propagate a wave through the reach. Experience showed that the restraint operating in this model was more severe. A more appropriate stability relationship is

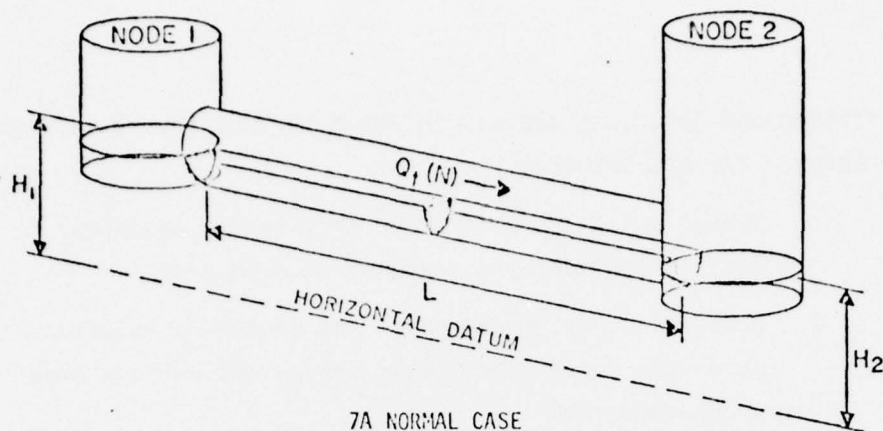
$$\Delta t \leq \frac{C' A_s Y_{\max}}{\Sigma Q} \quad (V-35)$$

where

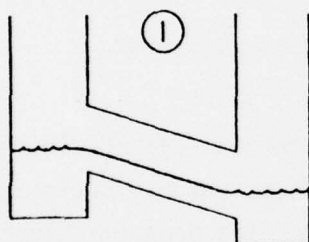
C' = constant determined by experience, usually about 0.10.

Physically, the cause of instability is too rapid a rise in the water surface. Equation V-35, with $C' = 0.10$, says that the rise in water surface during Δt should not exceed 0.10 of the depth available in the pipe. This criterion clearly is approximate and must be approached with caution.

Application of the finite difference form of the motion equation, Equation V-28, is not always straightforward because of some special conditions which may exist all or part of the time in a sewer. First, the invert elevations of pipes which join at a node may be different; sewers are built frequently with invert discontinuities. Second, critical depth may occur in the conduit. Third, normal depth may control. Finally, the pipe may be dry. In all of these cases, or combinations thereof, the flow must be computed by special techniques. Figure V-4 shows each of the

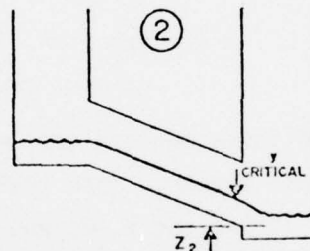


7A NORMAL CASE

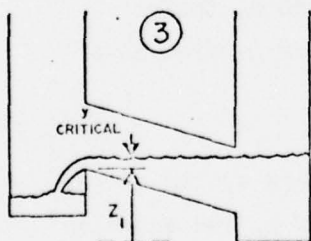


Normal Case

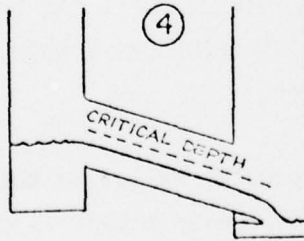
1. $H_1 = \text{Head @ Node 1}$
 $H_2 = \text{Head @ Node 2}$
2. Assign storage in regular manner



1. $H_1 = \text{Head at Node 1}$
 $H_2 = Y_{\text{critical}} + Z_2$
2. Assign all conduit storage operation

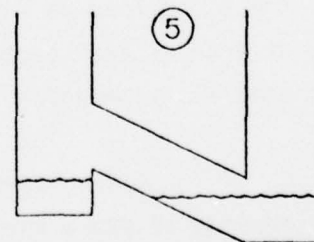


1. $H_1 = Y_{\text{critical}} + Z_1$
 $H_2 = \text{Head @ Node 2}$
2. Assign all conduit storage to downstream node



SUPERCritical FLOW

1. Use Normal Flow Value
2. Assign Storage in Regular Manner



1. $Q_{L+dt} = 0$
 $H_1 = 0$
 $H_2 = \text{Head at Node 2}$
2. Assign all conduit storage downstream

FIGURE V-4 HYDRAULIC CASES HANDLED BY TRANSPORT BLOCK

possibilities and describes the way in which surface area is assigned to the nodes. The options are:

1. *Normal case. Flow computed from motion equation; half of surface area assigned to each node.*
2. *Critical depth downstream. Use lesser of critical or normal depth downstream; assign all surface area to upstream node.*
3. *Critical depth upstream. Use critical depth; assign all surface area to downstream node.*
4. *Flow computed exceeds normal flow. Set flow to normal value; assign surface area in usual manner.*
5. *Dry pipe. Set flow to zero; if any surface area exists, assign to downstream node.*

Once these corrections are applied, the computations can proceed in the normal manner. Note that any of these special situations may begin and end at various times and places during simulation. The program detects these automatically.

The link-node computations can be extended to include devices which divert sanitary sewage out of the storm drainage system or relieve the storm load on sanitary interceptors. As treated here, these diversions are assumed to take place at a node, and are handled as a special, internodal transfer.

Weir diversions provide relief to the sanitary system during periods of storm runoff. Flow over a weir is computed by the equation

$$Q_w = C_w L_w \left[\left(h + \frac{v^2}{2g} \right)^a - \left(\frac{v^2}{2g} \right)^a \right] \quad (V-36)$$

where

- C_w = discharge coefficient,
- L_w = weir length,
- h = driving head on the weir,
- v = approach velocity, and
- a = weir exponent; $\frac{3}{2}$ for transverse weirs,
 $\frac{5}{3}$ for sideflow weirs

Both C_w and L_w are input values for transverse weirs. For sideflow weirs, C_w should be a function of the approach velocity, but the present version of the program does not include this.

Normally, the driving head on the weir is computed to be:

$$h = y_1 - y_c \quad (V-37)$$

where

- y_1 = water depth on upstream side of weir,
- y_c = height of weir crest above invert.

However, several other conditions can exist which modify the situation. If the downstream water depth, y_2 , also exceeds the weir crest height, the weir is submerged, and the flow computed by Equation V-36 is corrected according to Villemonte, i.e.,

$$Q_w' = Q_w \left[1 - \left(\frac{y_2 - y_c}{y_1 - y_2} \right)^a \right]^{0.385} \quad (V-38)$$

If the upstream pipe is surcharged, the weir will behave like an orifice, and the flow is computed by the equation

$$Q_w = C_w' L_w (y_{\max} - y_c) \sqrt{2gh + v^2} \quad (V-39)$$

where

- C_w' = discharge coefficient for submerged case, and
- y_{\max} = maximum flow depth.

This is almost equivalent to having the weir behave as an orifice. The coefficient C'_w is an input variable; as rule of thumb, it can be taken approximately equal to $\frac{1}{8} C_w$.

For all of the above cases, the direction of flow may be reversed under certain conditions which cause the "downstream" water surface to rise above the "upstream". This does not affect the equations, except that y_1 and y_2 are switched. However, the configuration of a sideflow is such that reversed flow is more nearly like a transverse weir; the weir coefficient, a , is adjusted to $\frac{3}{2}$ for this situation.

Frequently, weirs are installed together with a tide gate at points of overflow into the receiving waters. Flow across the weir is restricted by the tide gate, which may be partially closed at times. This is accounted for by reducing the effective driving head across the weir according to an empirical factor published by Armco in their design manual "Armco Water Control Gates"

$$h' = h - \frac{4}{9} v^2 e^{\frac{-1.15v}{\sqrt{h}}} \quad (V-40)$$

An orifice is usually installed as a dropout to divert sanitary sewage to an interceptor, out of the storm system, and to limit the flow of stormwater into the sanitary system. Flow through an orifice is governed by

$$Q_o = C_o A \sqrt{gh} \quad (V-41)$$

where

- C_o = discharge coefficient,
- A = cross-section area, and
- h = driving head on the orifice.

The driving head is usually the depth of flow in the upstream pipe, y_1 . For a few installations, when the orifice is side flowing instead of dropout,

the head difference $H_1 - H_2$ may control. The variables y and H are defined identically for orifices as for weirs, and backflow can occur.

A pump is represented conceptually as an off-line storage node (the wet well) from which the contents are pumped to another node according to a programmed rule curve. One, two or three stage pumping is permitted, and the turning on and off of the pumps is handled automatically.

The program simulates weir outfalls and free outfalls, both types with or without tide gates. The characteristics of the weir outfall were described above. The "free" outfall may be truly free, if the elevation of the receiving waters is low enough, or it may consist of a backwater condition. In the former case, the water surface at the free outfall is taken as critical or normal depth, whichever is less. If backwater exists, the receiving water elevation is taken as the value.

If a tide gate is present, the Armco correction Equation V-40, is applied to either the weir or free outfall case. The outflow is zero, of course, when the tidal elevation exceeds the water level in the pipe, because the gate is closed.

TRANSPORT QUALITY BLOCK

Water quality constituents are routed through the principal sewers by the Transport Quality Model. It is the simplest of the three models, and would be combined with the Transport Block except that computer storage requirements will not permit it.

Most of the movement of water quality constituents in the sewer system is by advective transport. The differential equation which describes this process is seen usually in one of two forms:

In terms of mass rate of change,

$$\frac{\partial M}{\partial t} = QC \quad (V-42)$$

where

M = mass, and

C = concentration.

In terms of concentration rate of change,

$$\frac{\partial C}{\partial t} = - \frac{C}{V} \frac{\partial V}{\partial t} + u \frac{\partial C}{\partial x} \quad (V-43)$$

where

V = volume.

These equations are completely interchangeable for our purposes; some aspects of both are used in the numerical solution.

The conceptual representation of advective transport is shown in Figure V-5. Conduit "n" with velocity u_n , connects nodes 1 and 2, which have pollutant concentrations of C_1^t and C_2^t , respectively, at time t. During time interval Δt , the initial concentration gradient will move at velocity u_n , so that it occupies the position shown by the dashed line at the time $t+\Delta t$. The value \hat{C} , which was the distance $u_n \Delta t$ away from node 2, becomes the new value at node 2, $C_2^{t+\Delta t}$.

This part of the advective transport process, which does not account for volume changes, can be expressed by writing only the last part of Equation V-43 in finite form; applicable to a conduit

$$\frac{\Delta C_j}{\Delta t} = u \frac{\Delta C_n}{L} \quad (V-44)$$

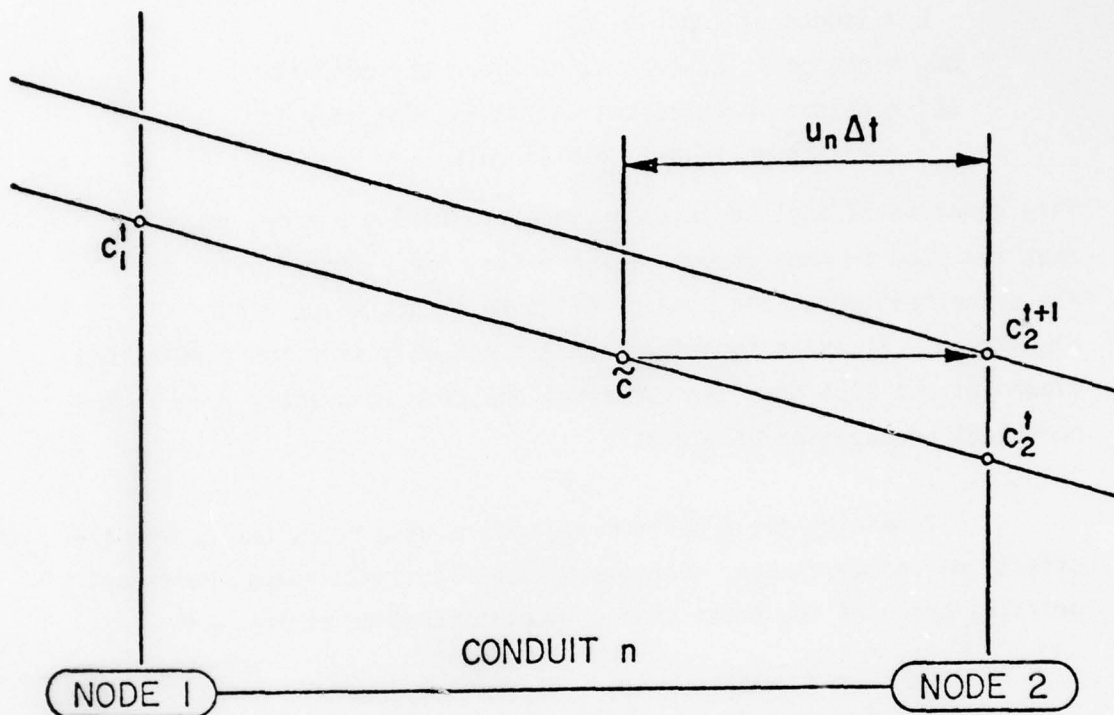


FIGURE V-5 ADVECTIVE MOVEMENT IN A CONDUIT

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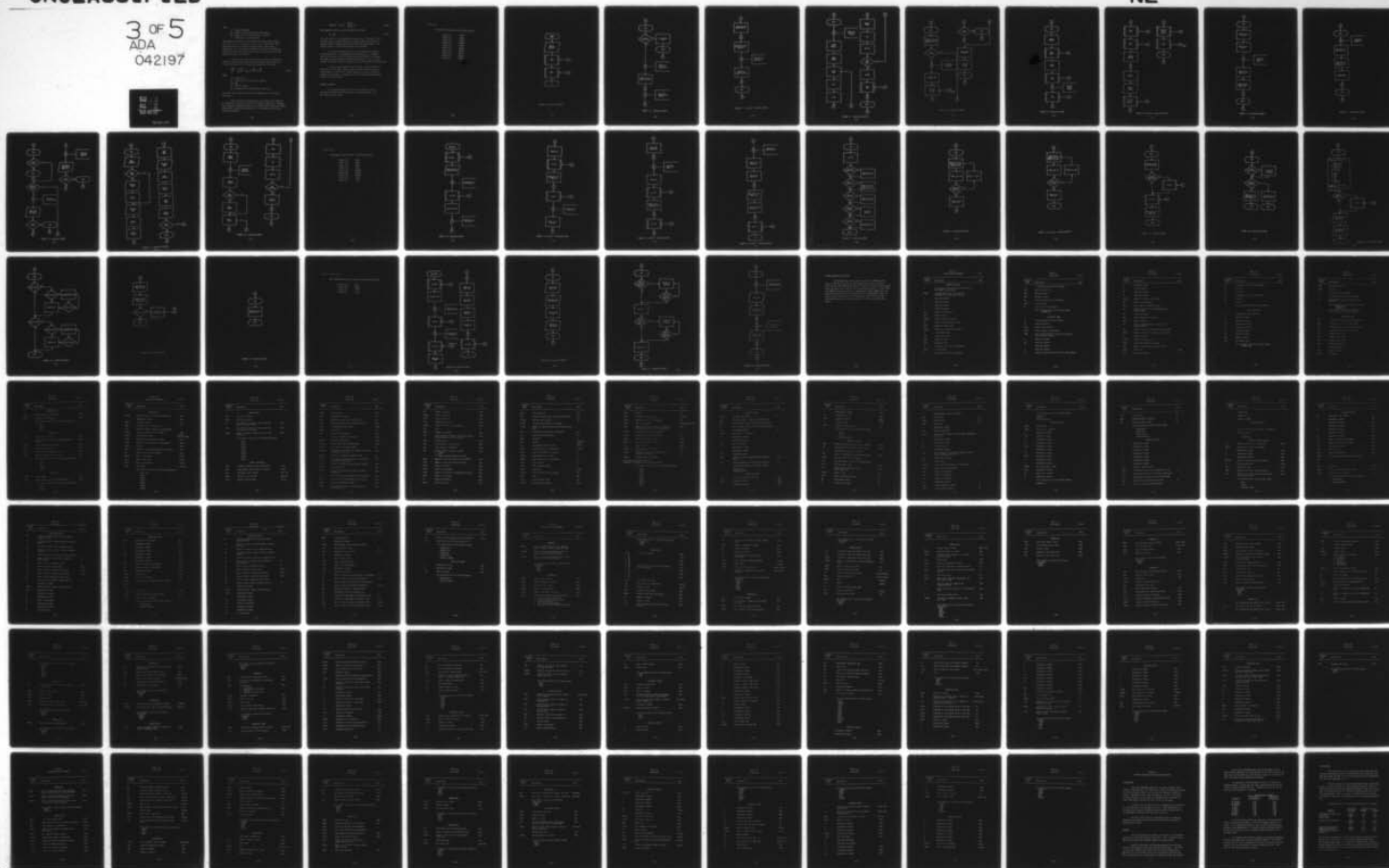
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where

- L = length of conduit
- ΔC_n = change in concentration along the conduit
- $\Delta C_j'$ = change in *nodal* concentration, due only to advection in a single conduit.

This equation is applied to each conduit entering a node, *provided that the flow in that conduit is into the node*. This implies that the concentration at the node is blind to events which occur downstream. It is an important concept not only from the theoretical viewpoint but also from the numerical one, for it greatly reduces the numerical propagation of errors.

Combining the conduit computations at a node, and adding the effects of volume change, source-sink contributions, pumps, weirs and orifices produces the total change in concentration at the node

$$\frac{\Delta C_j}{\Delta t} = - \frac{C_j}{V_j} \frac{\Delta V_j}{\Delta t} + \frac{1}{\alpha_n} \sum_u Q_n \frac{\Delta C_j}{\Delta t} + \sum_s \frac{\Delta C_j}{\Delta t} \quad (V-45)$$

where

- V_j = nodal volume,
- \sum_u = summation over all upstream conduits,
- $\alpha_n = \sum_u Q_n$
- Q_n = flow in conduit
- \sum_u = summation of all source-sinks, pumps, etc.

The latter term in Equation V-45 must be computed via a mass balance technique.

The time history of concentration at all nodes can be obtained by successively integrating Equation V-45 forward through time. Although many integration methods could be used, including the modified Euler method, the equation is quite well behaved and it is sufficient to perform the single step operation

$$\Delta C_j(t+\Delta t) = \Delta C_j(t) + \left(\frac{\Delta C_j}{\Delta t} \right)_t \Delta t \quad (V-46)$$

The integration step, Δt , must be restricted so that

$$\Delta t \leq \left| \frac{L}{u} \right| \quad (V-47)$$

for each conduit, or an unstable solution may occur. In practice, this restraint can be violated occasionally without causing the solution to become unstable, although some error must be introduced thereby. The program contains a trap to guard against the occurrence.

The Transport Block routes all of the constituents produced by the Runoff Block. It performs only a mass balance, i.e. products output by the Runoff Block are transferred without addition or deletion. Note especially that BOD does not decay during routing. This is a good assumption, because the total transport time can be expected to be quite short.

A more serious assumption, which results in some difficulty in simulation, is that sewer systems normally contain large quantities of stored material in the form of sludge deposits, grits, etc.; these are ignored by this program. Consequently, the "plug flow" phenomenon often observed is not reproduced.

PROGRAM FLOWCHARTS

The following figures are the program flowcharts for the subroutines included in the Runoff Block, the Transport Block, and the Transport Quality Block.

RUNOFF BLOCK

The Runoff Block contains the following figures:

Figure V-6	RUNOFF
Figure V-7	GQUAL
Figure V-8	GUTTER
Figure V-9	HCURVE
Figure V-10	HYDRO
Figure V-11	QSHED1
Figure V-12	QSHED2
Figure V-13	RECAP
Figure V-14	RHYDRO
Figure V-15	WSHED

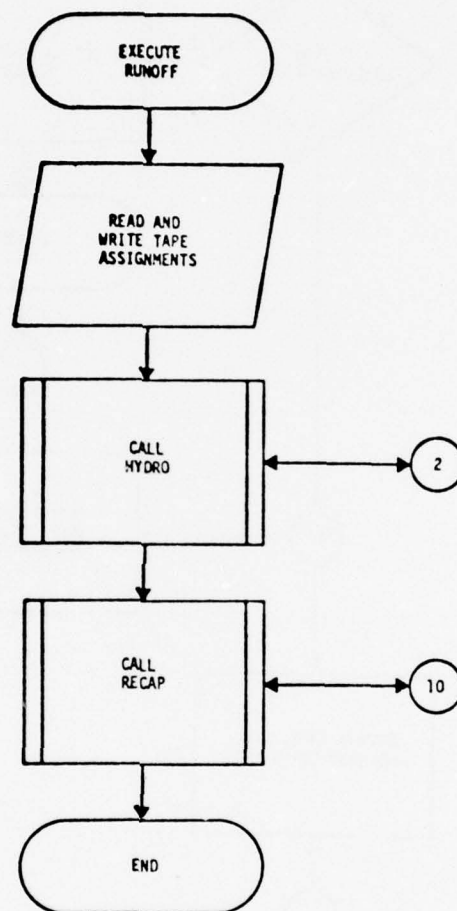


FIGURE V-6 Subroutine RUNOFF

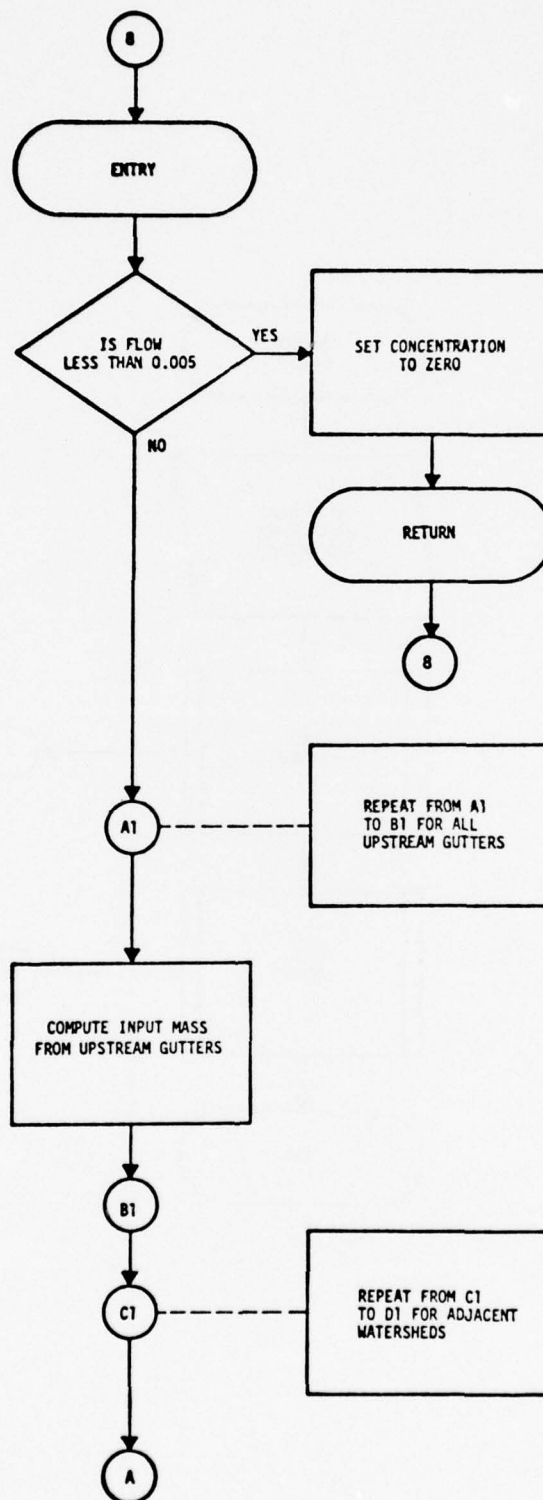


FIGURE V-7 Subroutine GQUAL

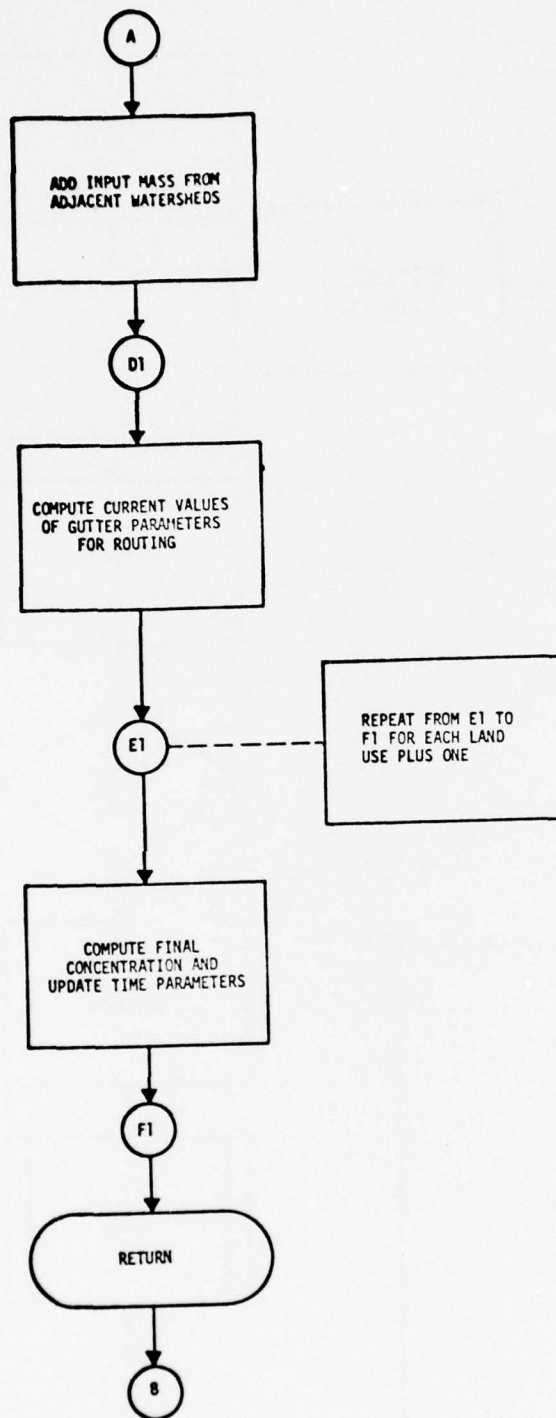


FIGURE V-7 (cont'd) Subroutine GQUAL

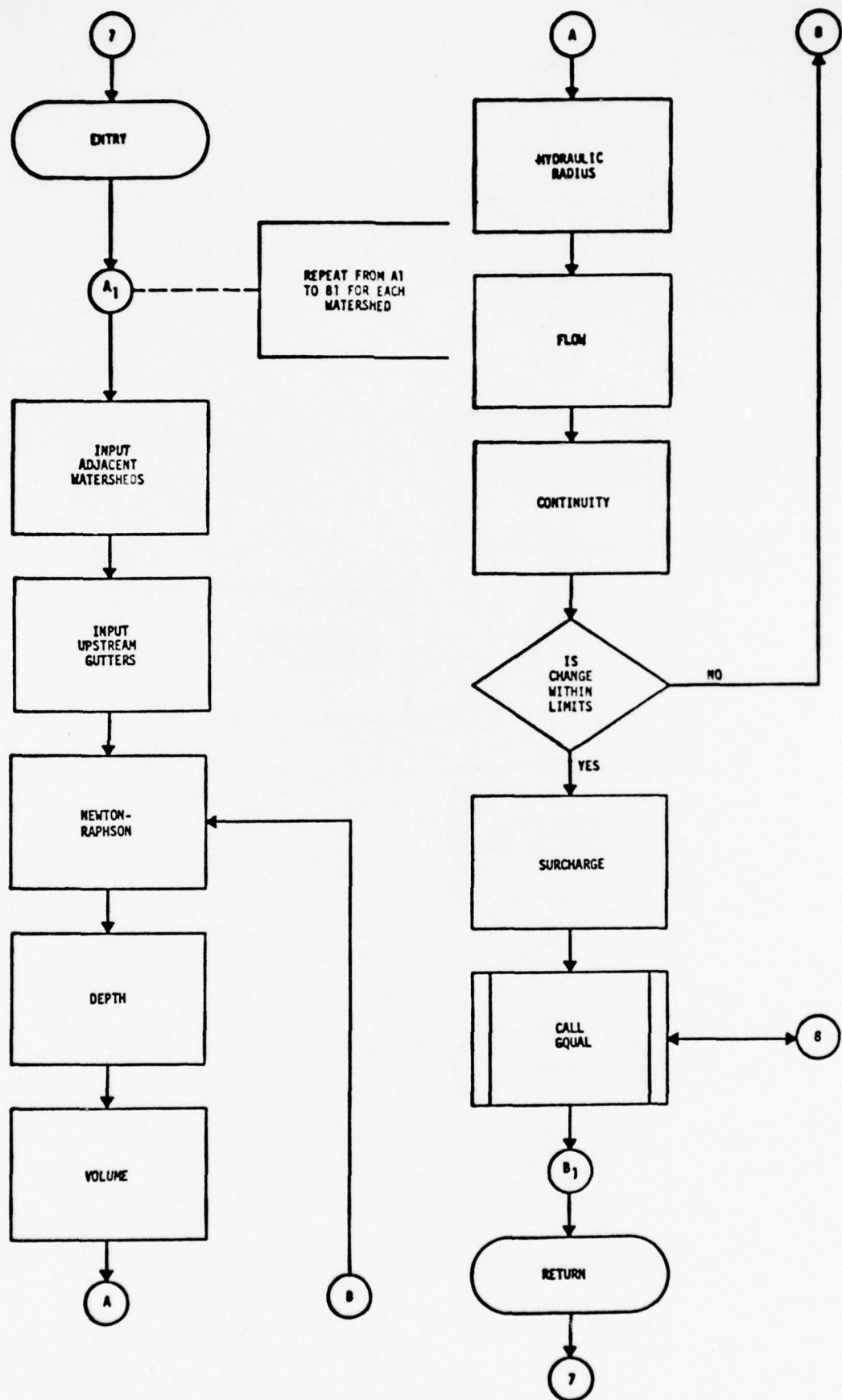


FIGURE V-8 Subroutine GUTTER

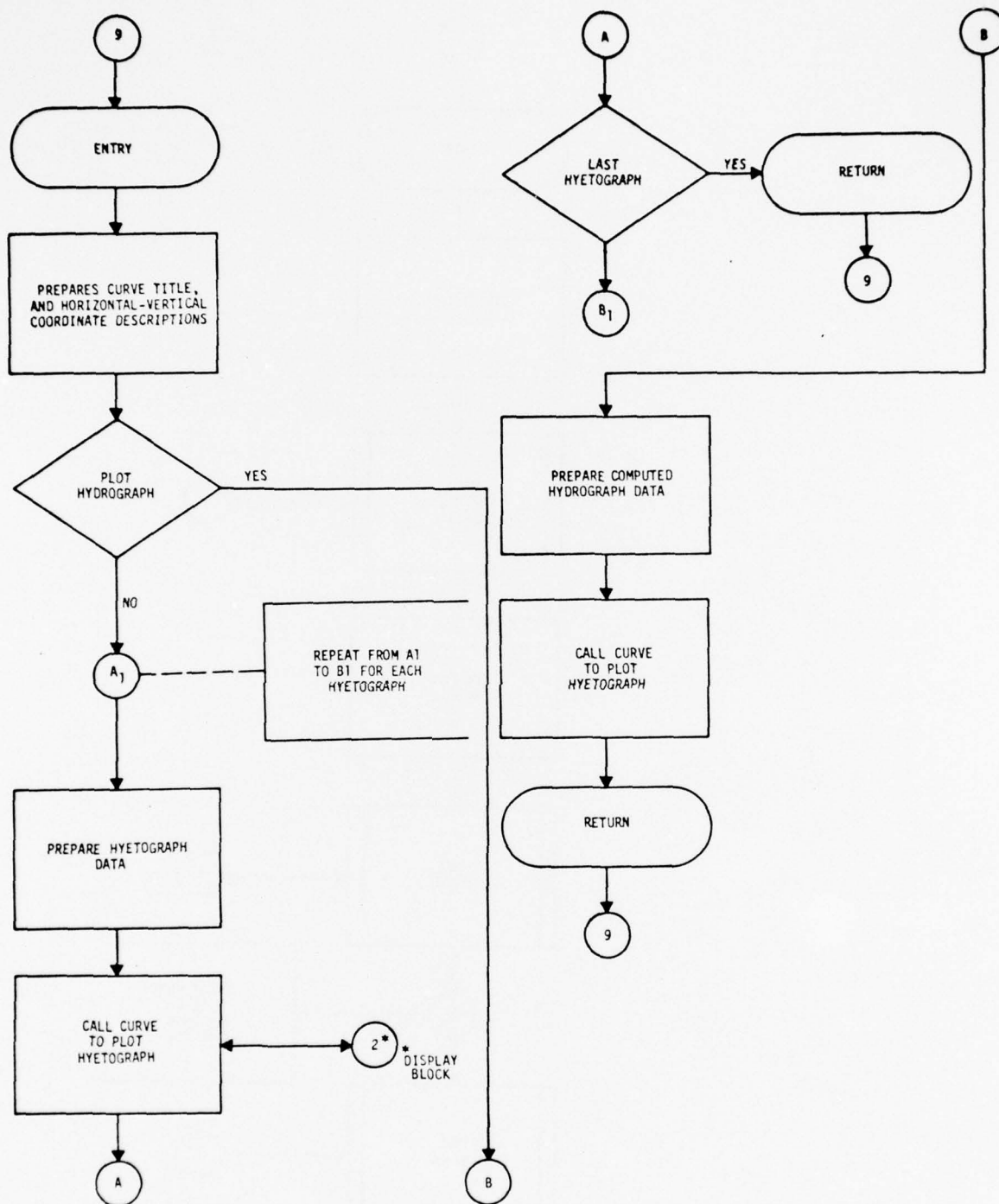


FIGURE V-9 SUBROUTINE HCURVE

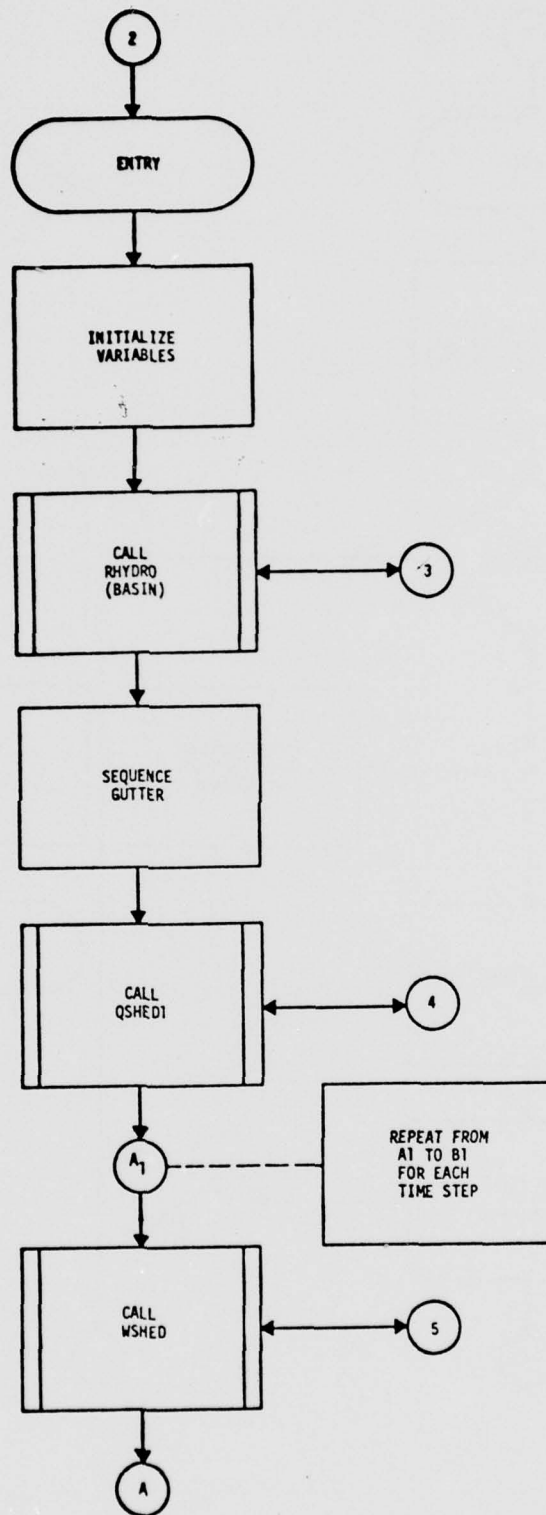


FIGURE V-10 Subroutine HYDRO

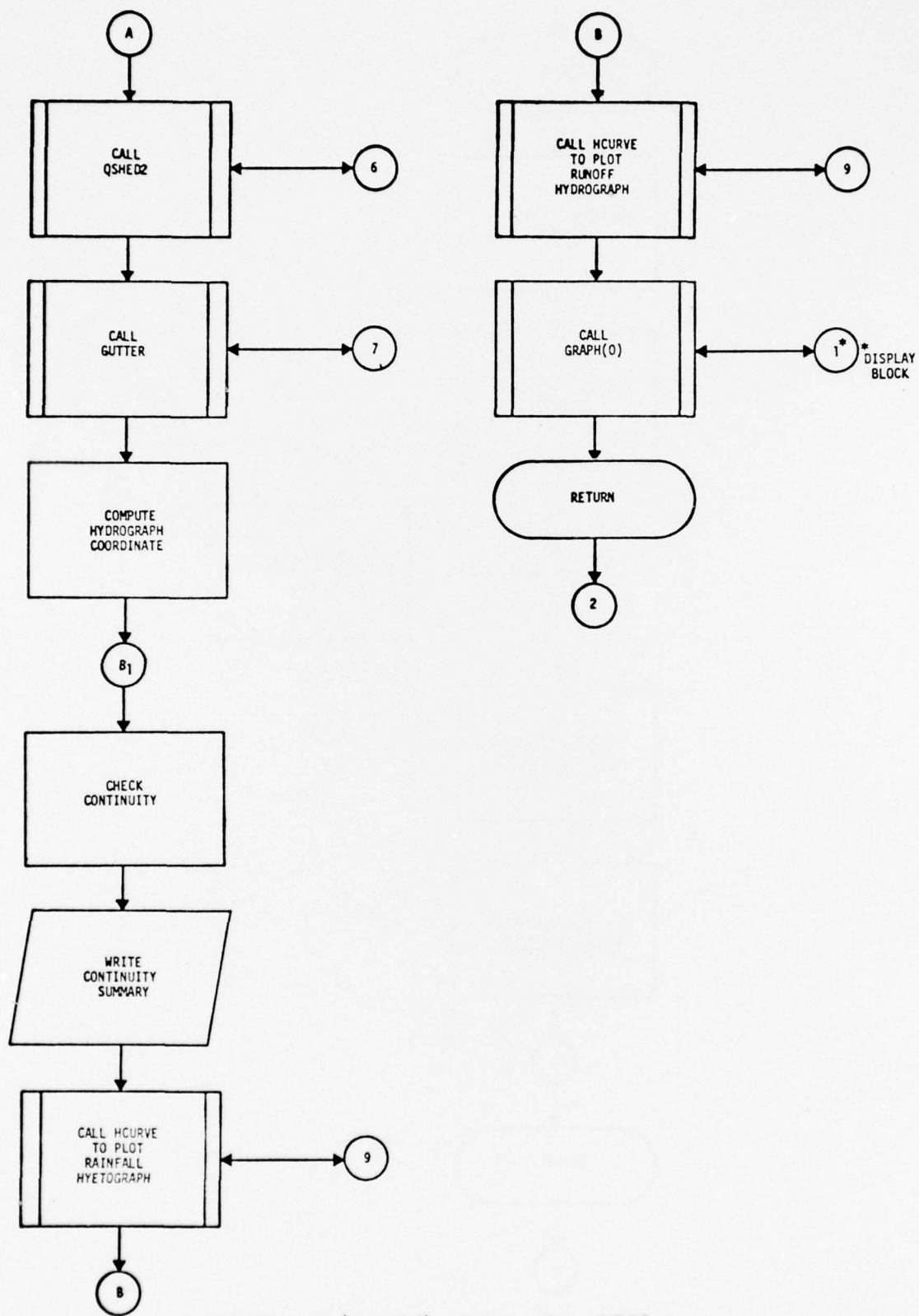


FIGURE V-10 (cont'd) Subroutine HYDRO

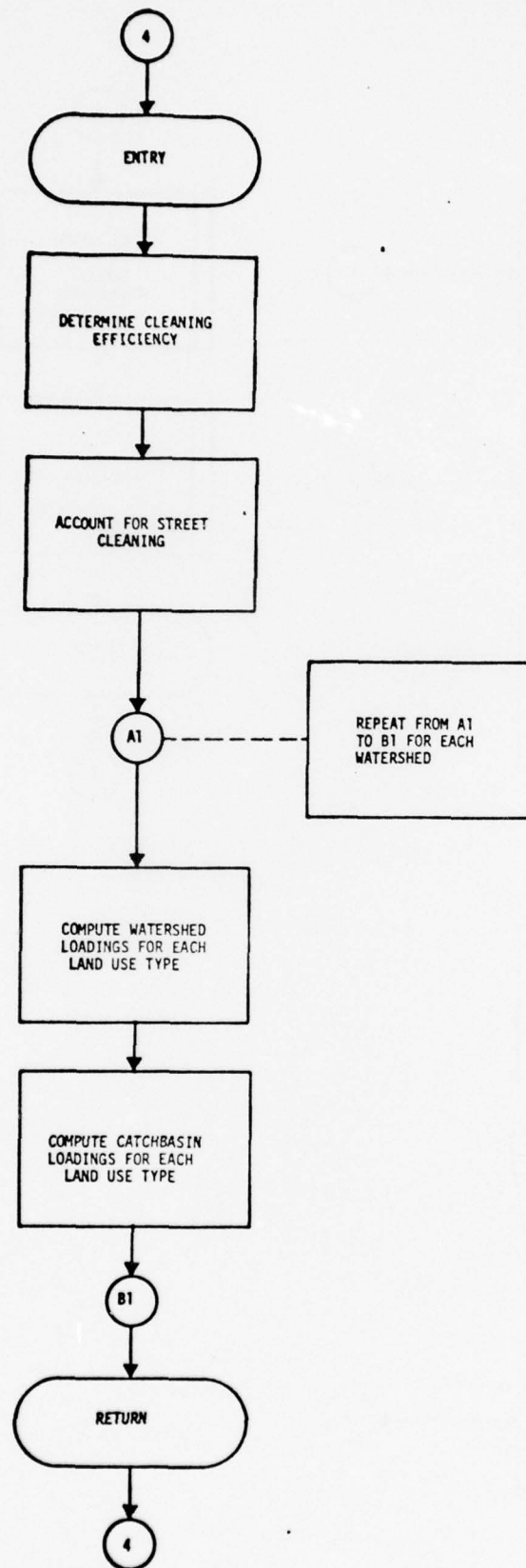


FIGURE V-11 Subroutine QSHED1

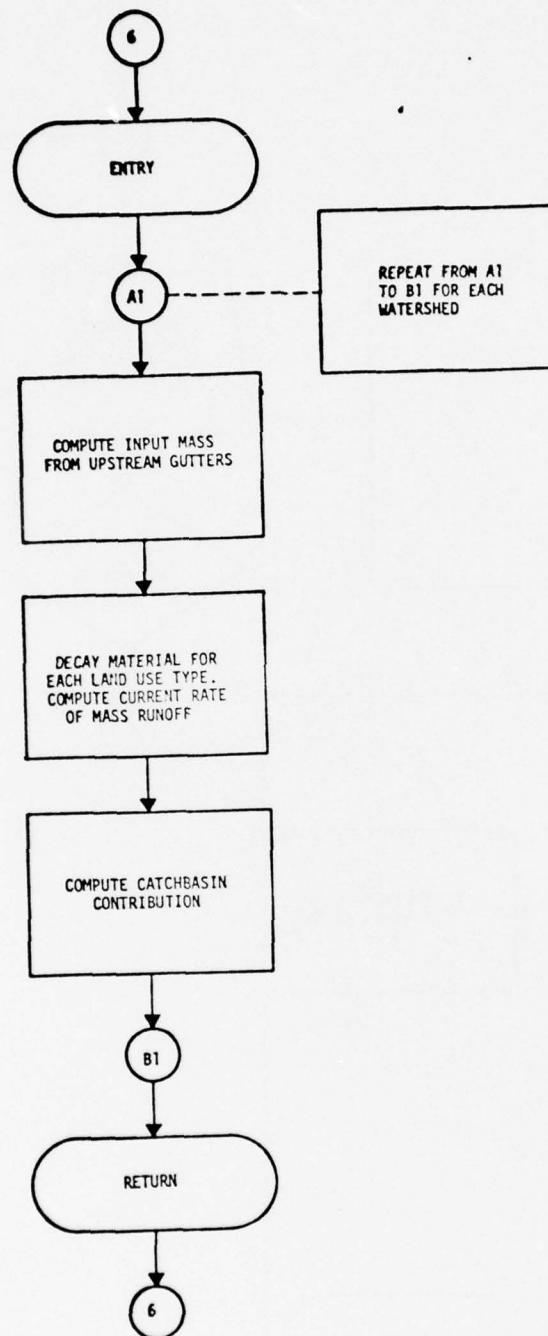


FIGURE V-12 Subroutine QSHED2

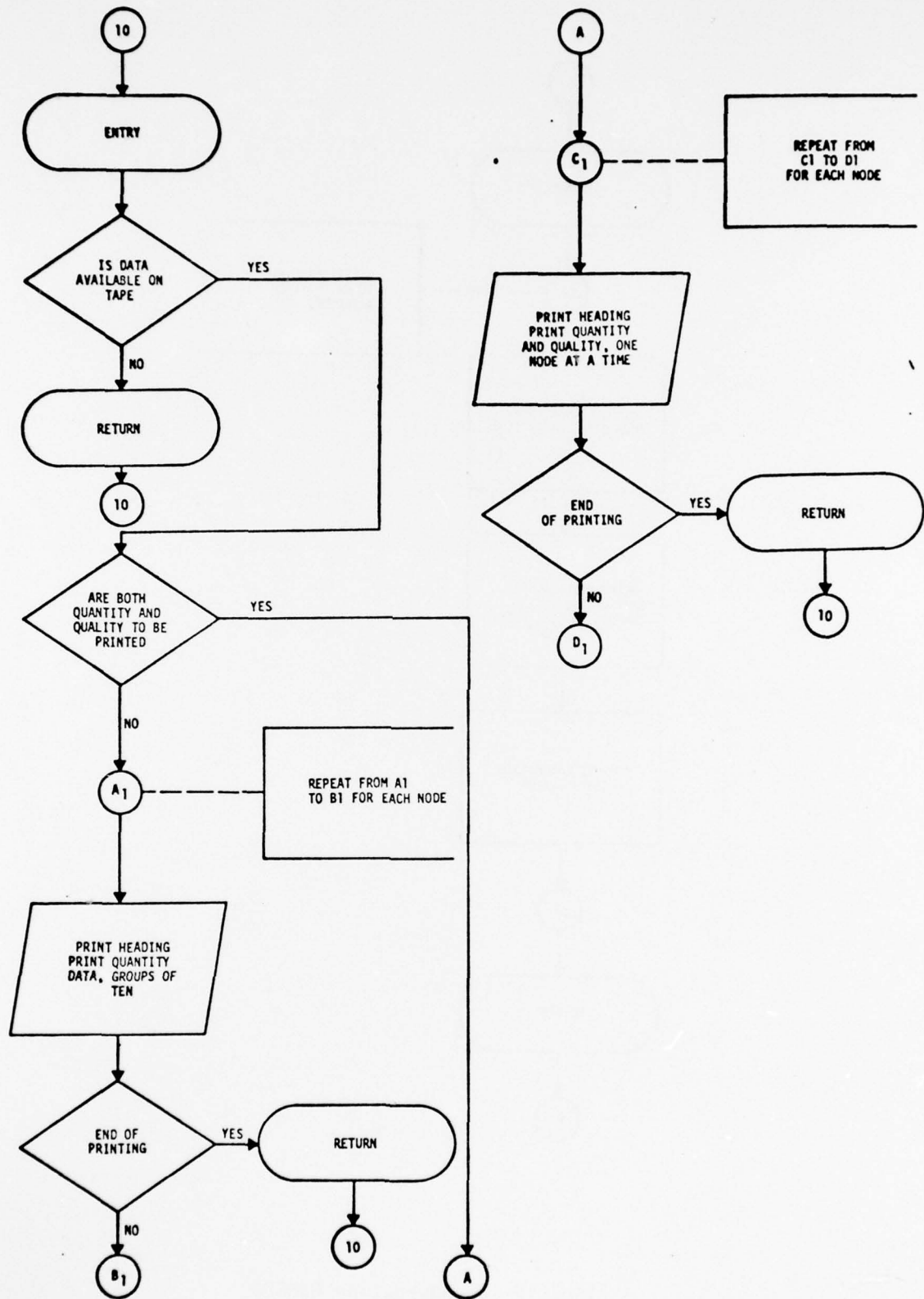


FIGURE V-13 Subroutine RECAP

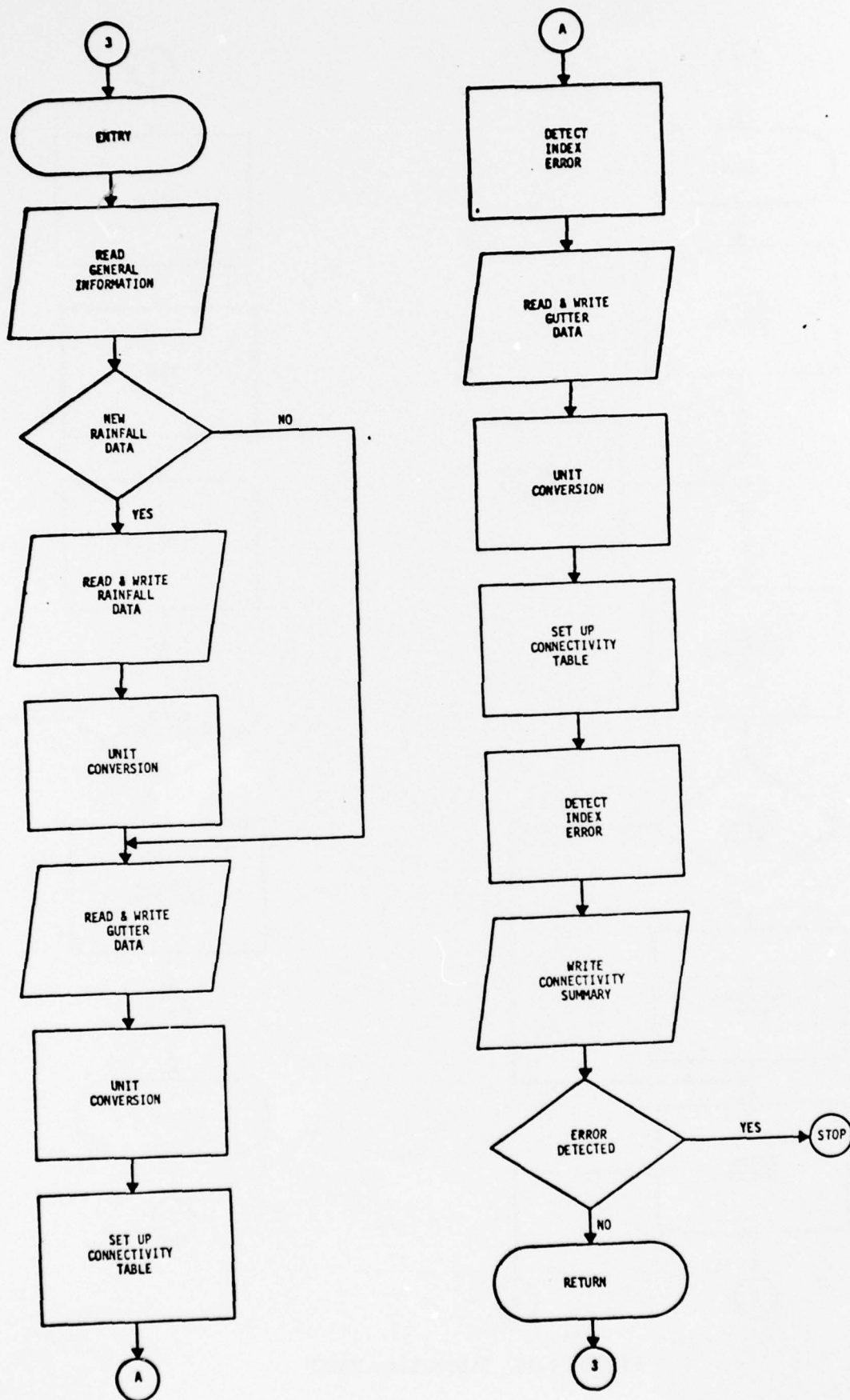


FIGURE V-14 Subroutine RHYDRO
V-37

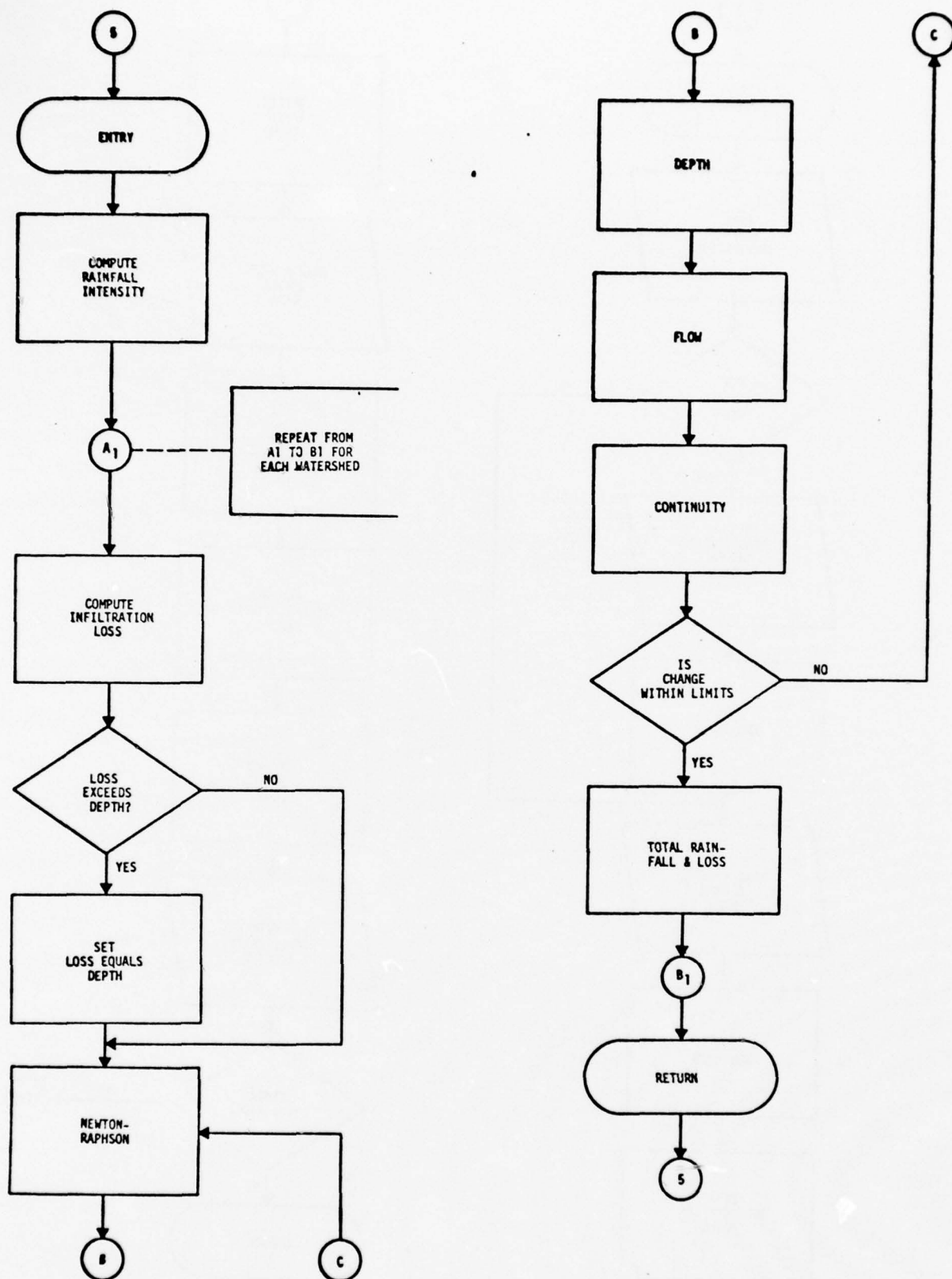


FIGURE V-15 Subroutine WSHED

TRANSPORT BLOCK

The Transport Block contains the following figures:

Figure V-16	MAIN
Figure V-17	BOUND
Figure V-18	DEPTH
Figure V-19	HEAD
Figure V-20	HYDRAD
Figure V-21	INDATA
Figure V-22	INFLOW
Figure V-23	OUTPUT
Figure V-24	TIDCF

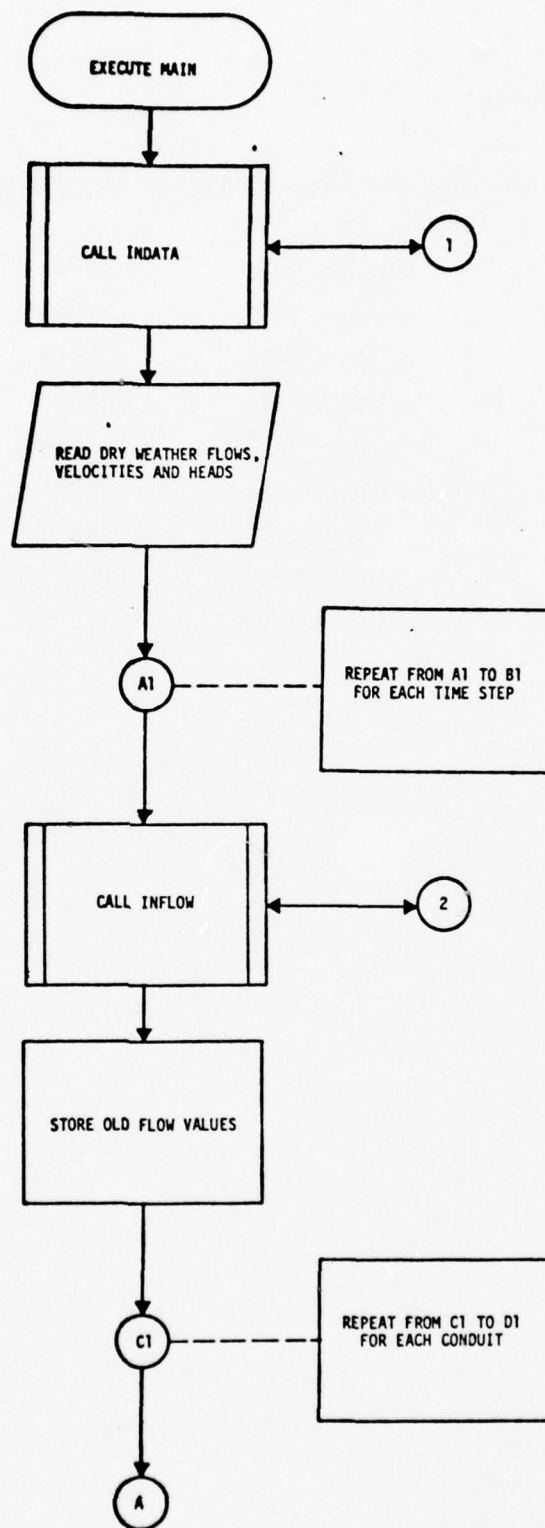


FIGURE V-16 Subroutine MAIN

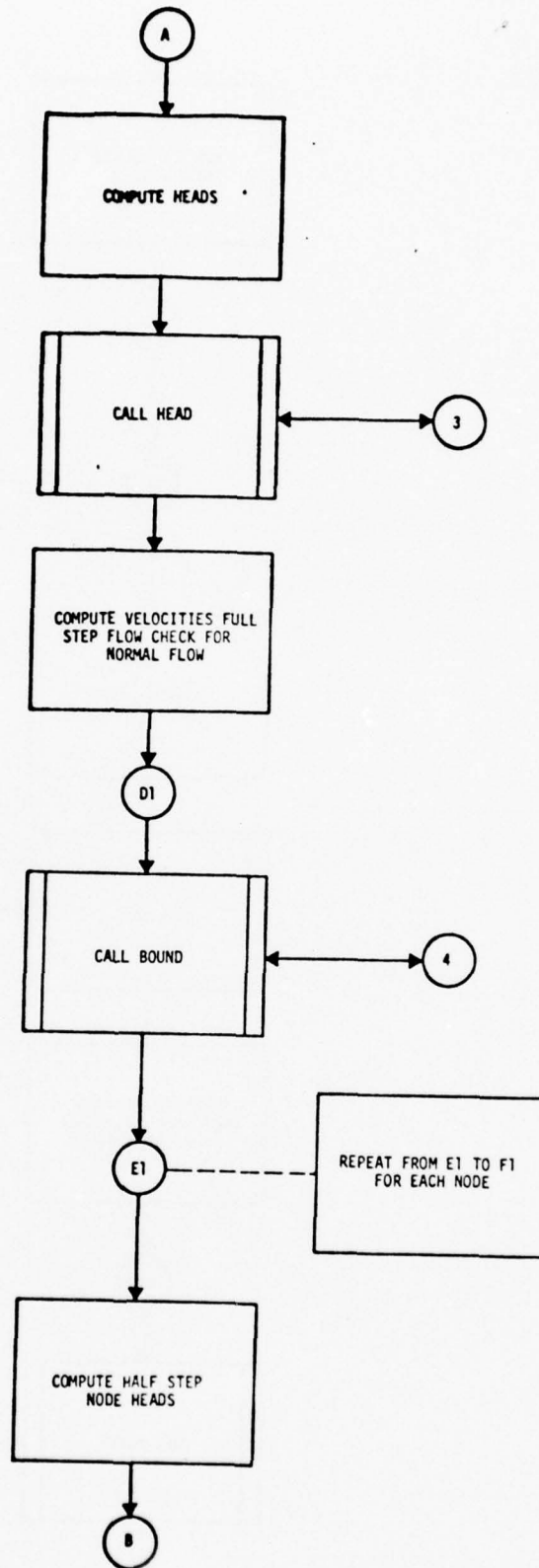


FIGURE V-16 (cont'd) Subroutine MAIN

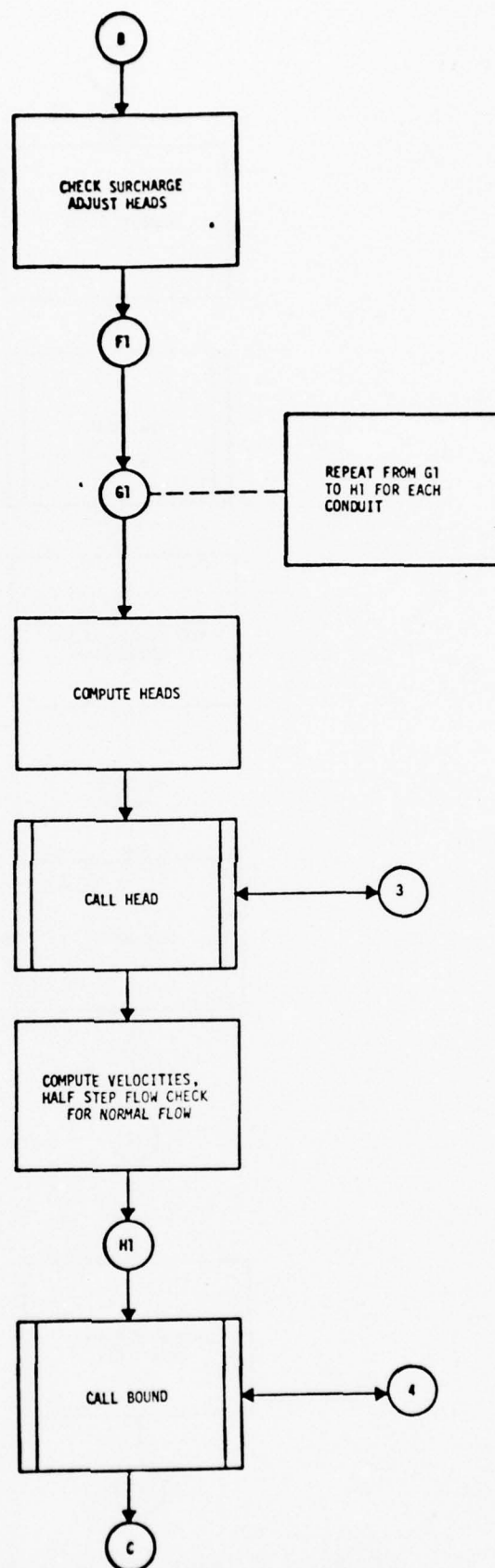


FIGURE V-16 (cont'd) Subroutine MAIN

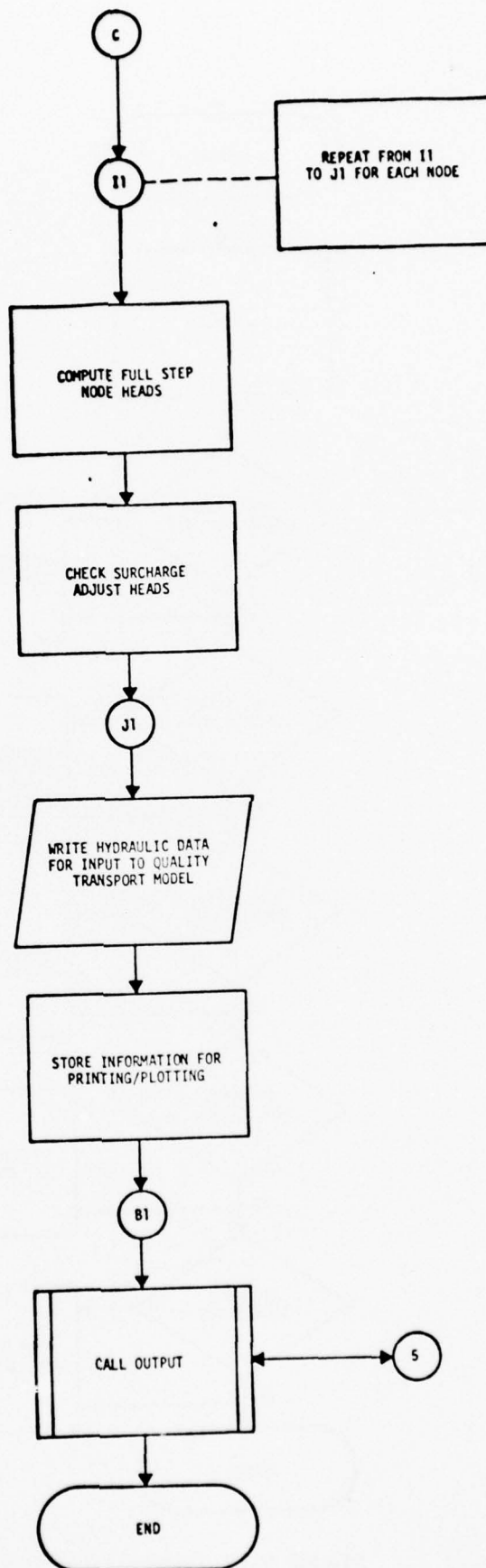


FIGURE V-16 (cont'd) Subroutine MAIN

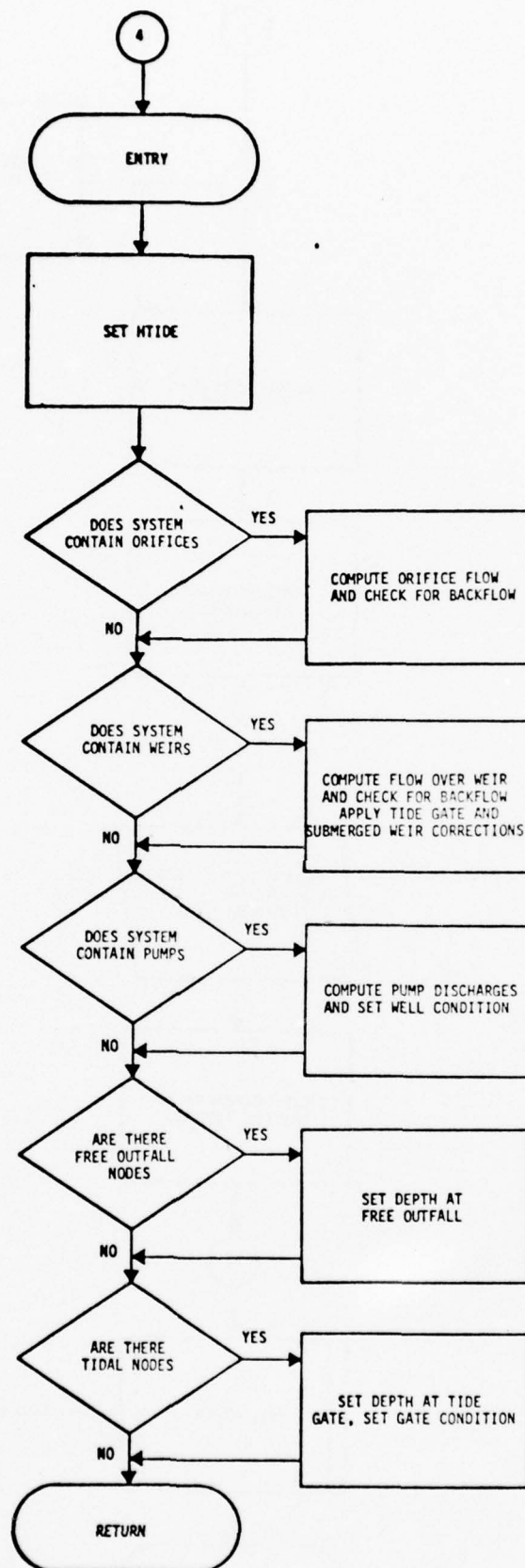


FIGURE V-17 Subroutine BOUND

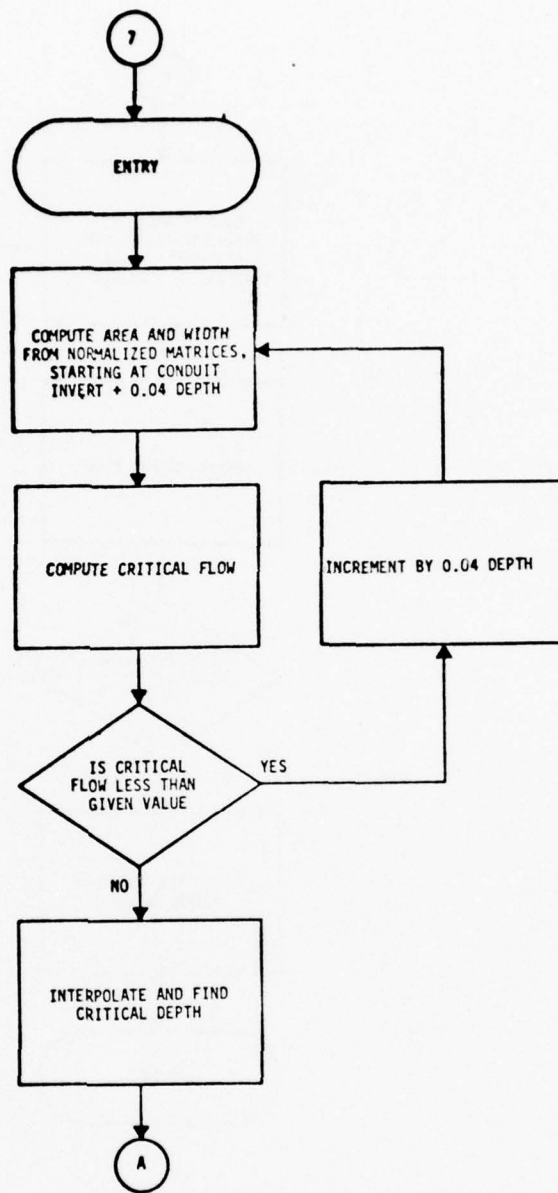


FIGURE V-18 Subroutine DEPTH

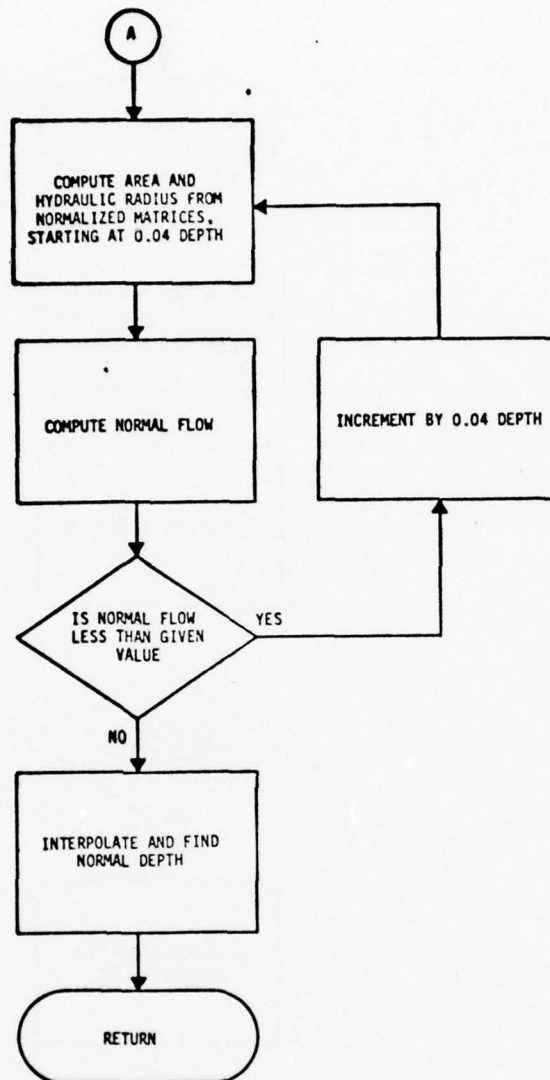


FIGURE V-18 (cont'd) Subroutine DEPTH

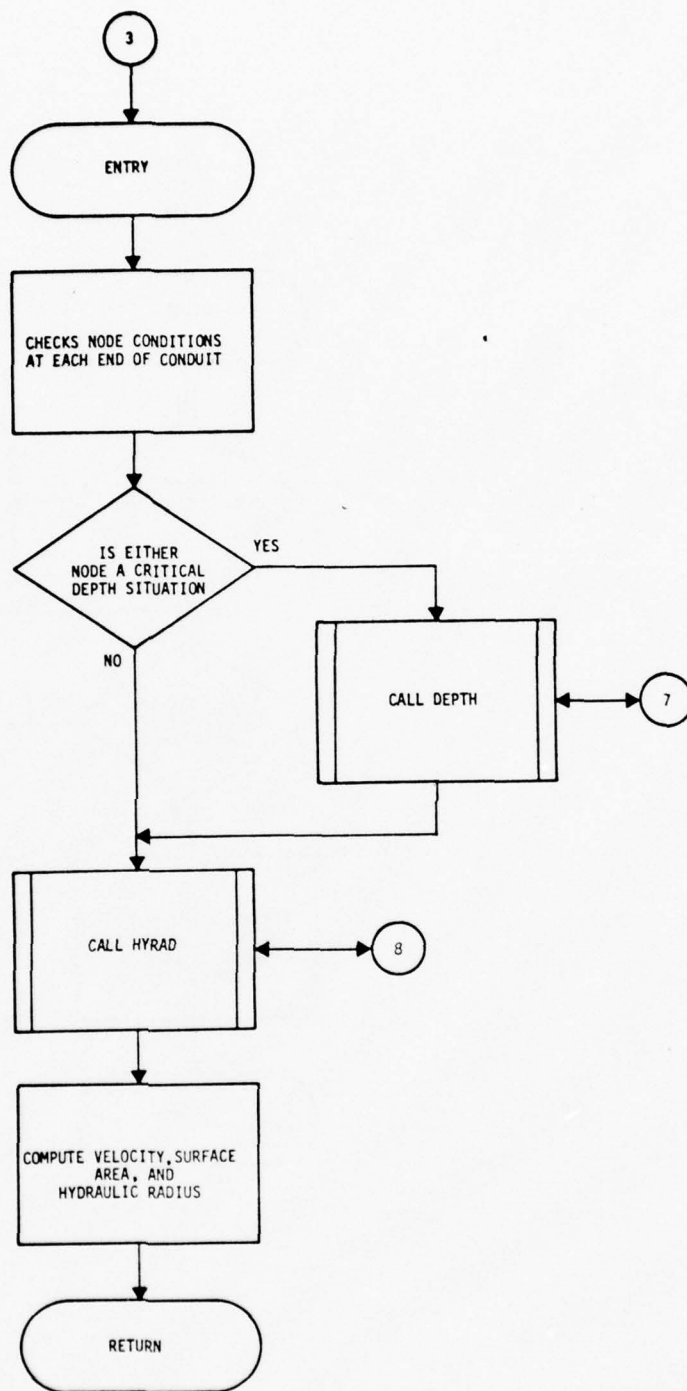


FIGURE V-19 Subroutine HEAD

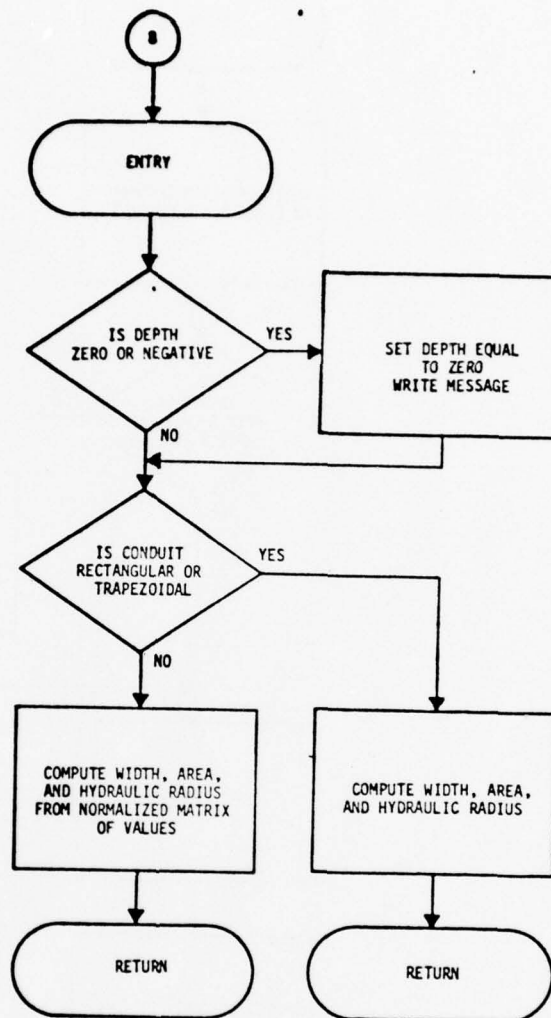


FIGURE V-20 Subroutine HYDRAD

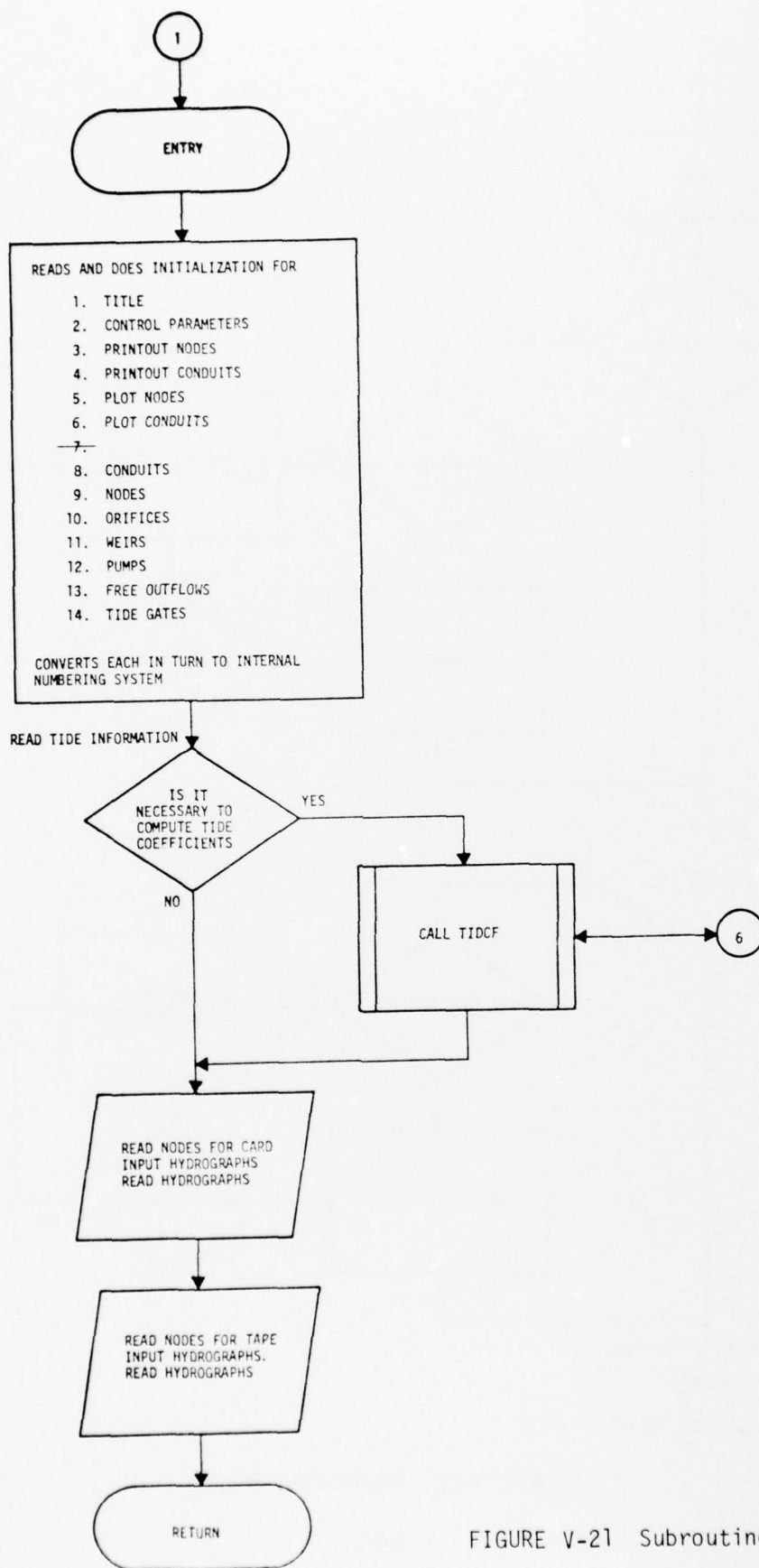


FIGURE V-21 Subroutine INDATA

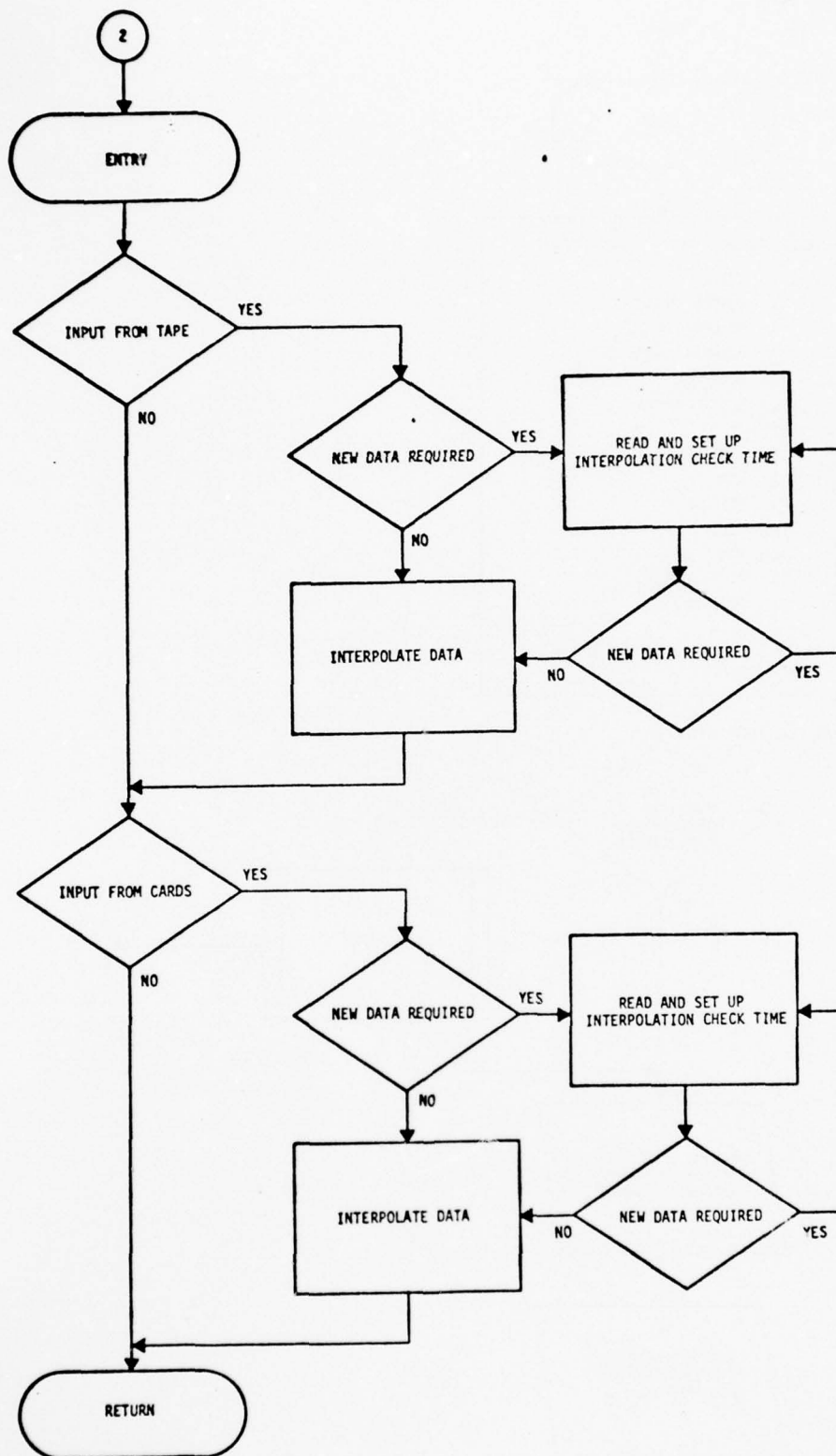


FIGURE V-22 Subroutine INFLOW

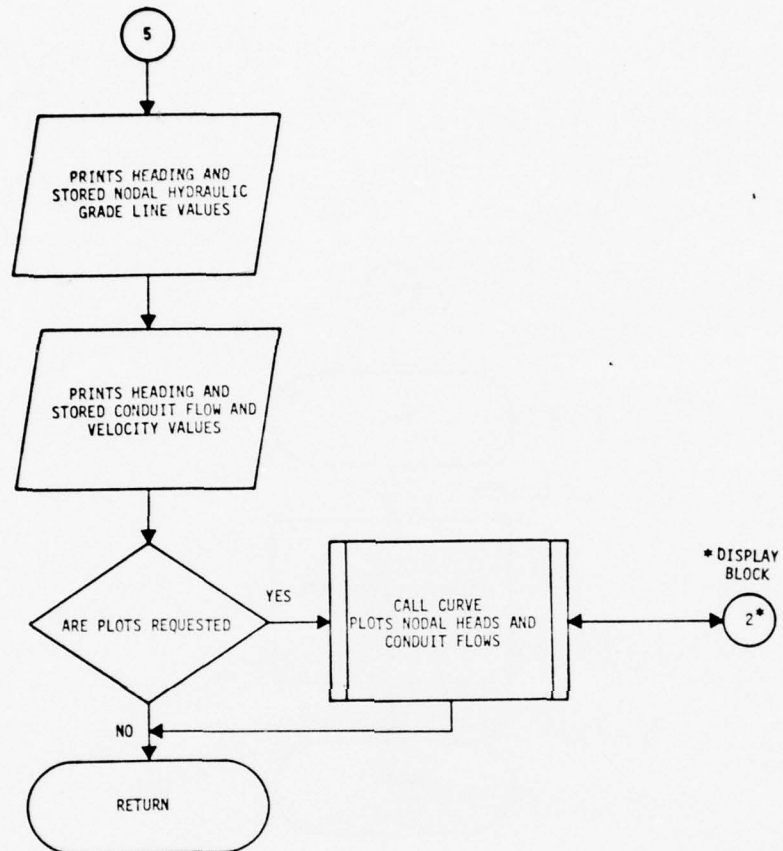


FIGURE V-23 Subroutine OUTPUT

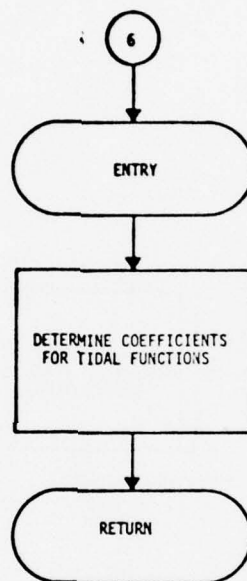


FIGURE V-24 Subroutine TIDCF

TRANSPORT QUALITY BLOCK

The Transport Quality Block contains the following figures:

Figure V-25	MAIN
Figure V-26	INDATA
Figure V-27	INPUT
Figure V-28	OUTPUT

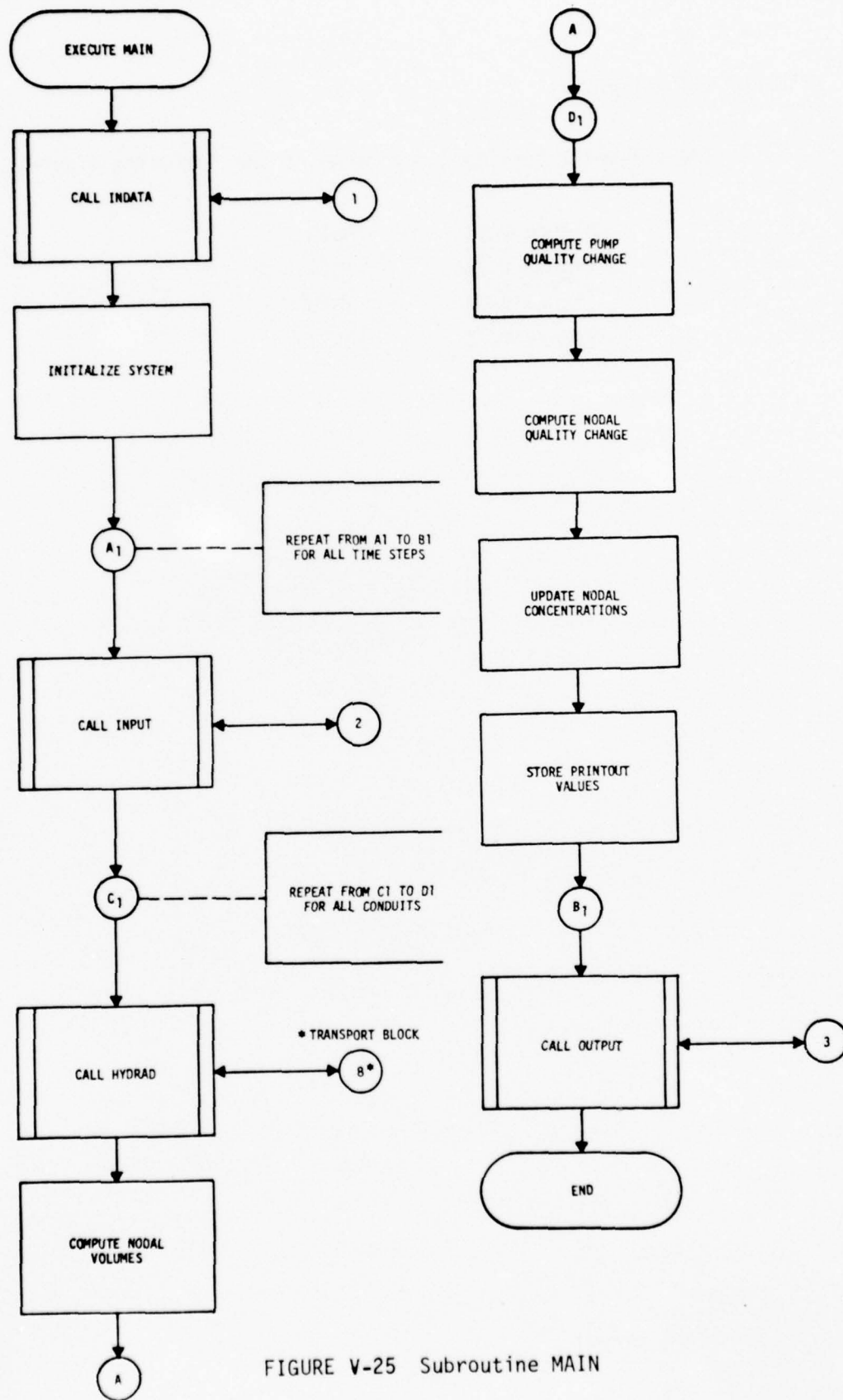


FIGURE V-25 Subroutine MAIN

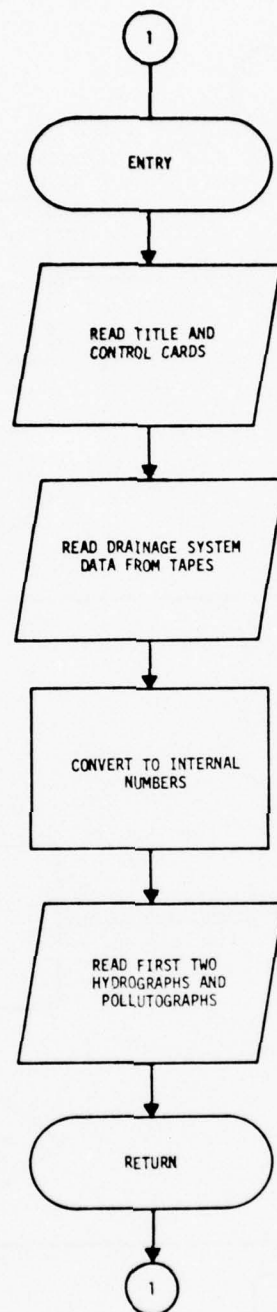


FIGURE V-26 Subroutine INDATA

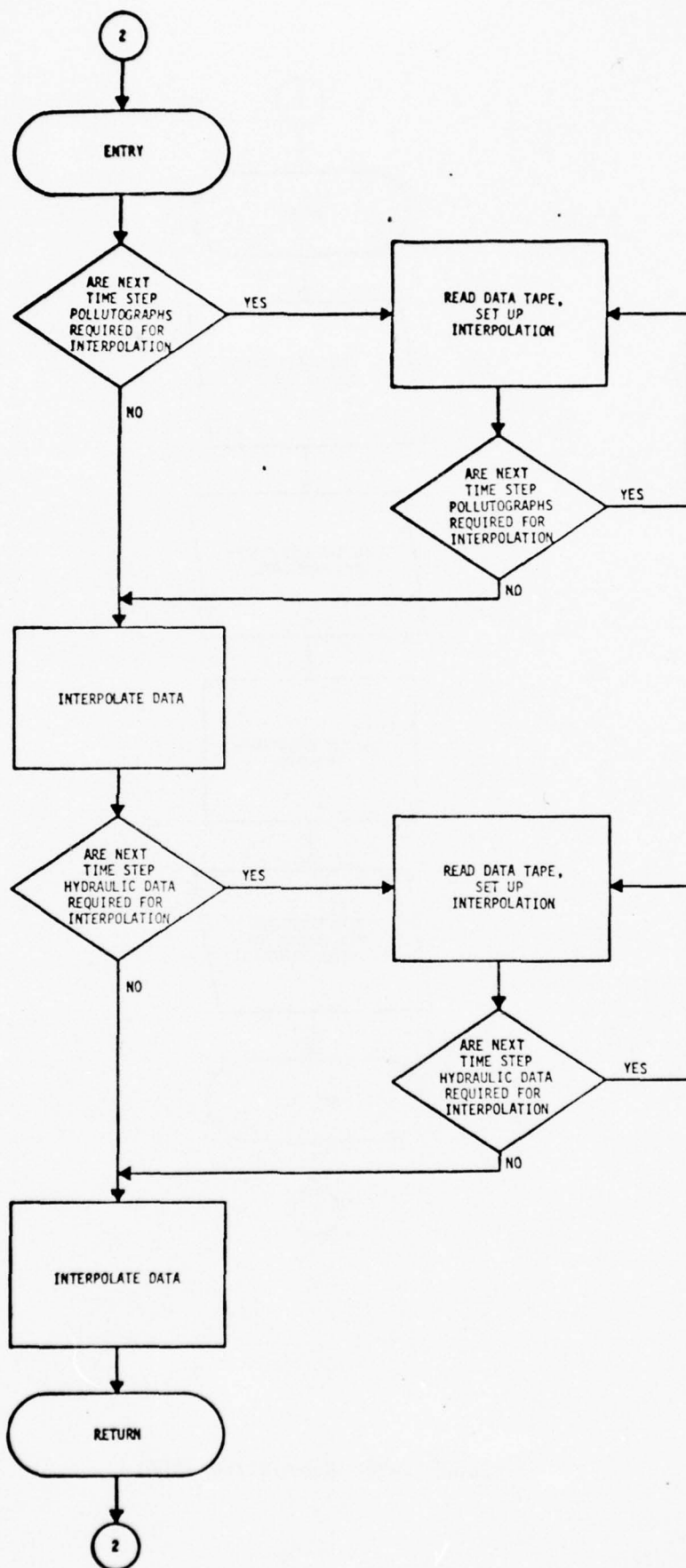


FIGURE V-27 Subroutine INPUT

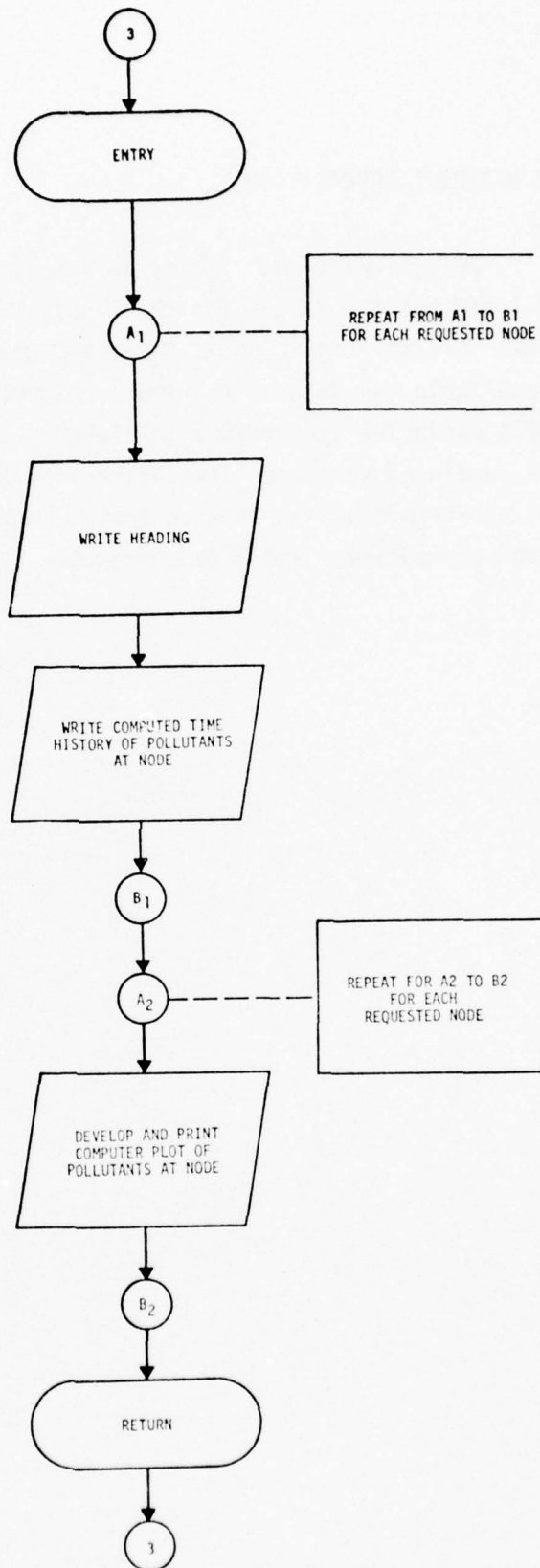


FIGURE V-28 Subroutine OUTPUT

PROGRAM VARIABLE DESCRIPTIONS

The following four tables define variables in FORTRAN storage. Table V-1 defines the values for the Display Block, Table V-2 defines the values for the Runoff Block, Table V-3 gives the values for the Transport Block, and Table V-4 is used for the Transport Quality Block. In each table the COMMON variables are defined in alphabetized labeled COMMON order, and then the remaining variables are defined for each alphabetized subroutine. There is cross-referencing in each table; each common block lists the associated subroutines, and each subroutine lists the associated common blocks.

TABLE V-1
DISPLAY BLOCK VARIABLES

1 of 5

Variable Name	Description	Unit
SUBROUTINE CURVE		
A	The log base 10 of the range of values of y coordinate to be plotted	
FRANG	Expanded range (even intervals) of y coordinates of curve to be plotted	
K	Subscript counter	
L	Subscript counter	
M	Subscript counter	
N	Subscript counter	
NCV	Number of curves/plot	
NPLOT	Number of plots	
NPOINT	Number of points on a plot	
NPT	Number of points/curve (array)	
NPTM	Numerical value of NPT	
RANGE	Range of y values to be plotted	
X	X coordinate array	
XINT	Label interval for X	
XMAX	Maximum X value	
XMIN	Minimum X value	
XO	Start point of line (X coordinate)	
XSCAL	X scale factor	
XT	End point of line (X coordinate)	

TABLE V-1
(Continued)

2 of 5

Variable Name	Description	Unit
Y	Y coordinates of curves to be drawn	
YINT	Label interval for Y	
YMAX	Maximum Y value	
YMIN	Minimum Y value	
Y0	Start point of line (Y coordinate)	
YSCAL	Y scale factor	
YT	End of line (Y coordinate)	
	This subroutine uses the following common: COMMON/LAB/	

SUBROUTINE GRAPH

IC	Calling sequence control parameter
II	Subscript counter
ILAB	Output label with plot
IPL0T	Array of nodes to be plotted
ITAB	Array indicating which locations of the data file are to be plotted
J	Subscript counter
JJJ	Subscript counter
K	Subscript counter
L	Subscript counter
LX	Transfer location from data file to plot storage

TABLE V-1
(Continued)

3 of 5

Variable Name	Description	Unit
M	Subscript counter	
MC	Do loop counter	
MM	Subscript counter	
N	Subscript counter	
NCURVE	Number of curves to be plotted	
NCV	Number of curves/plot	
NLOC	Node number of hydrograph point	
NLP	Number of types of plot (hydrographs and pollutographs)	
NN	Subscript counter	
NPCV	Maximum number of curves/plot	
NPLOT	Number of plots	
NPT	Array containing number of points to be plotted (GRAPH)	
NQP	Number of quality constituents to be plotted	
NQUAL	Number of quality constituents on data file	
NR	Subscript counter	
NSTEPS	Number of steps in plot	
NTAPE	Input tape number for plotting	
NVAL	Number of points/data record on a file	
TAREA	Total area	acres
TDEL	Time-step interval	

TABLE V-1
(Continued)

4 of 5

Variable Name	Description	Unit
XA	X increment used for interpolation	
X1	Same as X0	
X2	Same as XT	
YA	Y increment used for interpolation	
Y1	Same as Y0	
Y2	Same as YT	
This subroutine does not use any common.		

SUBROUTINE PLOT

A	Transfer array for plotting
I	Subscript counter
II	Subscript counter
IX	Start point of line
IY	Start point of line
J	Subscript counter
JJ	Subscript counter
NCT	Number of plots
SYM	Plot symbol array
This subroutine uses the following common:	
COMMON/LAB/	

TABLE V-1
(Continued)

5 of 5

Variable Name	Description	Unit
TIMES	Time-step interval	
TZERO	Zero time	
X	X coordinate array (GRAPH)	
Y	Y coordinates of curves to be drawn	
YT	Hydrograph-pollutograph information on data file	
	This subroutine uses the following common: COMMON/TAPES/ COMMON/LAB It also has its own blank common which overlays main program blank common.	

SUBROUTINE PINE

AXA	X coordinate of value previously plotted
AXG	X coordinate of value to be plotted
AYA	Y coordinate of value previously plotted
AYB	Y coordinate of value to be plotted
IXA	Integer value of AXA
IXB	Integer value of AXB
IYA	Integer value of AYA
IYB	Integer value of AYB
N	Subscript counter
NCT	Number of plots
NSYM	Plot number

TABLE V-2
(Continued)

2 of 17

Variable Name	Description	Unit
COMMON/INFIL/		
DEPIN	Maximum allowable infiltration	inches
RAININ	Summation of infiltration	inches
	This common is used in the following subroutines:	
	HYDRO	
	RHYDRO	
	WSHED	
COMMON/LAB/		
HORIZ	Curve label for x-axis	none
IT	Internal control variable subroutine HCURVE (PLOT)	none
TITLE	Title printed out with graphs	none
VERT	Curve label for y-axis	none
XLAB	Numerical scale labels for x-axis	none
YLAB	Numerical scale labels for y-axis	none
	This common is used in the following subroutines:	
	CURVE	
	GRAPH	
	HCURVE	
	PLOT	
COMMON/NEW/		
NAMEG	Gutter member	none
NGTO	Gutter member to which watershed drains	none
	This common is used in the following subroutines:	
	GUTTER	
	RHYDRO	

TABLE V-2
RUNOFF BLOCK VARIABLES

1 of 17

Variable Name	Description	Unit
COMMON/ABLK/		
BASINS	Equivalent number of standard catchbasins	none
C	Removal coefficient	none
CBFACT	Catchbasin factor	none
CBVOL	Volume of liquid in catchbasin	CF
CDOT	Internal variable, change in concentration	
CLFREQ	Interval between street cleanings	days
DDFACT	Dust and dirt factor	lbs/day/ 100 ft. gutter
DRYDAY	Number of dry days prior to storm	days
GQLEN	Number of feet of gutter in subcatchment	100 ft
KLAND	Land use	none
NPASS	Number of streetsweeper passes per cleaning	none
NQS	Number of quality constituents	none
PBASIN	Mass in catchbasins	grams
POFF	Rate of mass runoff	gr/sec.
PSHED	Mass on subcatchment	grams
QFACT	Flow factor	mg/gram

This common is used by the following subroutines:

BLOCK DATA
GQUAL
GUTTER
HYDRO
QSHED1
QSHED2
RHYDRO

TABLE V-2
(Continued)

3 of 17

Variable Name	Description	Unit
COMMON/TAPES/		
INCNT	Not used at present	
IOUTCT	Not used at present	
JIN	Unit member of magnetic tape or drum/disc used for non-card input	none
JOUT	Unit member of magnetic tape or drum/disc used for non-card output	none
NSCRAT	Number of magnetic tape or drum/disc used internally	none
This common is used in the following subroutines:		
GQUAL		
GRAPH		
GUTTER		
HYDRO		
QSHEDI		
RHYDRO		
RECAP		
RUNOFF		
COMMON (UNLABELED)		
DECAY	Exponential decay rate for infiltration	1/sec
DELD	Instantaneous pipe diameter in radians	radian
DELT	Integration time interval	sec, min
DELT2	One half of a time step	sec, min
DFULL	Gutter's maximum depth	inches

TABLE V-2
(Continued)

4 of 17

Variable Name	Description	Unit
DUMMY*	Dummy Variable	none
FLOW	Hydrograph flow value	cfs
FLOW	Temporary variable for printing flow	cfs
GCON	Manning's equation less hydraulic radius	none
GDEPTH	Instantaneous gutter depth	inches
GFLOW	Gutter flow	cfs
GLEN	Length of gutter/pipe	feet
GN	Manning's roughness coefficient	none
GSLOPE	Slope of gutter/pipe	ft/ft
GS1, GS2	Gutter side slope, left and right	ft/ft
GWIDTH	Pipe diameter or gutter width	ft
HGRAPH*	Magnitude of variable to be printed in vertical coordinate of the curve	none
HISTOG	Length of histogram expressed in time	sec
HTIME*	Time interval to be printed in the horizontal coordinate of the curve	none
IPLT	Numbers of gutters and inlets to be plotted	none
INTCNT	Printing counter	none
INTERV	Interval integrization cycles for printed hydrographs	none
IPRNT	Points for which hydrographs will be printed	none
ISAVE	Points for which hydrographs will be saved	none
NAMEW	External subcatchment number	none
ICODE	Plot control integer, zero means no plot, one means plot	none

TABLE V-2
(Continued)

5 of 17

Variable Name	Description	Unit
NG	Number of gutters	none
NGTOG	Gutter connections	none
NGTOI	Inlet connections	none
NGUT	Bookkeeping integer	none
NHISTO	Number of rainfall time intervals	none
NHR	Hour	hr
NHYET	Number of hyetograph	none
NIN	Maximum number of gutters draining to gutter, and watersheds draining to gutter	none
NING	Do loop counter	none
NOG	Total number of gutters/pipes	none
NOW	Total number of watersheds	none
NPG	Control switch for type of gutter 1. regular 2. pipe 3. dummy connected directly to inlet	none
NPLOT	Number of inlets and gutters to be plotted	none
NPRNT	Number of time steps between printing	none
NRAIN	Number of rainfall	none
NRGAG	Number of hyetographs	none
NSAVE	Number of points where hydrographs are saved	none
NSTEP	Number of time steps	none
NW	Number of watershed	none
NWTOG	Gutter connection	none

TABLE V-2
(Continued)

6 of 17

Variable Name	Description	Unit
NWTOI	Inlet connection	none
OUT	Temporary variable for printing concentration	mg/l
OUTFLW	Flow out of the gutter	cfs
PCIMP	Percent imperviousness of watershed	%
PCTZER	Percent of impervious area with zero detention depth	%
QUAL	Concentration of quality constituents	mg/l
QIN	Input from upstream gutter	cfs
QSUR	Surcharge	cf
RAIN	Rainfall	in/hr and ft/sec
RI	Instantaneous rainfall rate	ft/sec
RLOSS	Infiltration loss, instantaneous	ft/sec
SUMI	Total infiltration into ground	cf
SUMOFF	Total gutter flow @ inlet	cf
SUMQW	Total flow for each subcatchment	cf
SUMR	Total rainfall	cf
SUMST	Total surface storage	cf
TAREA	Total area	acres
THISTO	Time of rainfall time intervals	min
TIME	Time	sec
TIME2	Time minus half step	sec
TITLE**	Description of problem	none

TABLE V-2
(Continued)

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Variable Name	Description	Unit
TMIN	Minute	min
TRAIN	Time when rainfall ends	min/sec
TZERO	Starting time of the hydrograph	sec
WAREA	Area of watershed	acres/square foot
WCON	Modified Manning's equations, impervious and pervious portions of the watershed	none
WDEPTH	Instantaneous depth on watershed	ft
WFLOW	Instantaneous flow on watershed	cfs
WLMAX	Maximum infiltration rate	in/hr
WLMIN	Minimum infiltration rates	in/hr
WN	Dummy variable	none
WSLOPE	Average slope of watershed	ft/ft
WSTORE	Minimum and maximum storage depth on surface of watershed	ft
WWIDTH	Average width of watershed	ft

*USED ONLY IN HCURVE AND HYDRO
 **USED ONLY IN QSHED1, HYDRO, RECAP AND RHYDRO

This common is used in the following subroutines:

GQUAL
 GUTTER
 HCURVE
 HYDRO
 QSHED1
 RHYDRO
 WSHED

TABLE V-2
(Continued)

8 of 17

Variable Name	Description	Unit
SUBROUTINE WSHED		
DCORR	Time-step water depth	ft
DEL	Time-step change in depth of watershed flow	
DELR	Newton-Raphson change in depth for correction	
DF	Sum of volume change plus flow change times time	
DØ	Instantaneous depth	ft
EXPON	Decay times time interval	
F	Bookkeeping integer	
I	Bookkeeping integer	
IND	Rain time period	
J	Bookkeeping integer	
K	Bookkeeping integer	
NGAG	Hyetograph number	
WAR	Impervious area of watershed with immediate runoff	sq ft
WFLO	Average watershed flow during time interval	cfs
	This subroutine uses the following common:	
	COMMON/INFIL/ Unlabeled COMMON	
SUBROUTINE GQUAL		
ALFA	Half of integration time step	1/sec
BETA	Interval variable	$\frac{mg}{1-sec}$
K	Bookkeeping integer	none

TABLE V-2
(Continued)

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Variable Name	Description	Unit
L	Bookkeeping integer	none
M	Bookkeeping integer	none
TEMP	Internal variable	$\frac{\text{sec}}{\text{cu ft}}$
V	Storage volume	cu ft
VDOT	Change in storage rate	cfs
This subroutine uses the following common:		
/ABLK/		
/TAPES/		
UNLABELED COMMON		
SUBROUTINE GUTTER		
AX0	Trapezoidal cross-sectional area, starting	sq ft
AX1	Trapezoidal cross-sectional area, final	sq ft
D	Computational variable, internal	
DAX1	Change in trapezoidal cross-sectional area	sq ft
DDELV	Rate of change in volume change	
DEL	Time-step change in depth of watershed flow	
DELV	Average volume change	cu ft
DF	Sum of volume change plus flow change times time	cu ft
DFLOW1	Change in flow	cfs
DWP1	Change in wetted perimeter	ft
D0	Instantaneous depth	ft
D1	Estimated final depth	ft

TABLE V-2
(Continued)

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Variable Name	Description	Unit
F	Newton-Raphson volume correction	
FLOW	Average flow	cfs
FLOW0	Starting flow	cfs
FLOW1	Final flow	cfs
I	Bookkeeping integer	
IFLG	Surcharge indicator	
INLETS	Same as NSAVE, number of points where hydrographs are saved	
J	Bookkeeping integer	
K	Bookkeeping integer	
MOD	Library function	
N	Bookkeeping integer	
NOGG	Sum of number of gutters plus number of points where hydrographs are saved	
NOUT	Output file variable	
NQT	Same as NQS,	
NTIMEH	Hour of day of simulation (24-hour clock)	hr
NTSCP	Number of times surcharged	
NTS1	Output file variable	
NTS2	Output file variable	
NT1	Output file variable	
NX	Bookkeeping integer	
RAD0	Starting hydraulic radius	ft
RAD1	Final hydraulic radius	ft

TABLE V-2
(Continued)

11 of 17

Variable Name	Description	Unit
------------------	-------------	------

This subroutine uses the following common:

COMMON/LAB/

Unlabeled Common

SUBROUTINE HYDRO

BASIN	Basin number
ERROR	Name of error statement
I	Bookkeeping integer
IEOF	Indicator integer
II	Bookkeeping integer
IJ	Bookkeeping integer
ISUB	Bookkeeping integer
J	Bookkeeping integer
JK	Bookkeeping integer
KSPOT	Bookkeeping integer
M	Bookkeeping integer
N	Bookkeeping integer
NRANVL	Rain data points limiter
NSPOT	Bookkeeping integer
NT1	Output file variable
NX	Bookkeeping integer

This subroutine uses the following common:

COMMON/ABLK/

TABLE V-2
(Continued)

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Variable Name	Description	Unit
TMX	Time in hours	hr
WP0	Wetted perimeter, starting	ft
WP1	Wetted perimeter, final	ft
This subroutine uses the following common:		
Common/ABLK/		
Common/NEW/		
Common/TAPES/		
Unlabeled Common		
SUBROUTINE HCURVE		
I	Bookkeeping integer	
J	Bookkeeping integer	
JT	Bookkeeping integer	
K	Bookkeeping integer	
L	Bookkeeping integer	
M	Bookkeeping integer	
N	Bookkeeping integer	
NGAGP	Number of graphic points	
ORIZ	Horizontal title unit for hydrograph in time	hr
TITEL	Description of curve in horizontal coordinates	
TITL	Description of curve in vertical coordinates	
TMAX	Maximum time to be printed on curve	hr
VER	Vertical title unit for hydrograph	

TABLE V-2
(Continued)

13 of 17

Variable Name	Description	Unit
------------------	-------------	------

COMMON/INFIL/

COMMON/TAPES/

Unlabeled COMMON

SUBROUTINE PRESET

This is a block data subroutine. It uses the following common:

COMMON/ABLK

SUBROUTINE QSHED1 & QSHED2

DD	Mass of dust and dirt on watershed	grams
DFACT	Decay term for mass on watershed	
J	Bookkeeping integer	none
K	Bookkeeping integer	none
N	Bookkeeping integer	none
NCLEAN	Number of cleanings during dry period	none
R	Flow from watershed	in/sec
RATE	Runoff mass rate	l/sec
REFF	Removal efficiency in decimal percent	none
TGS	Parameter to account for mass accumulation in spite of cleaning	none

This subroutine uses the following common:

/ABLK/

/TAPES/

Unlabeled COMMON

TABLE V-2
(Continued)

14 of 17

Variable Name	Description	Unit
SUBROUTINE RECAP		
DELT	Integration time interval	sec
J	Bookkeeping integer	none
K	Bookkeeping integer	none
M	Bookkeeping integer	none
MAX	Bookkeeping integer	none
N	Bookkeeping integer	none
NLT	Bookkeeping integer	none
NPTS	Number of points to be plotted	none
NQS	Number of quality constituents	none
NRD	Bookkeeping integer	none
NREAD	Same as NSTEP	none
NSTEP	Number of time steps	none
NTIMEH	Hour of day of simulation (24-hour clock)	hr
NTX		
NT1		
TAREA	Total area	acres
TIMEM	Time of simulation (24-hour clock)	min
TZERO	Start time of hydrograph	sec

This subroutine uses the following common:

COMMON/TAPES/
Unlabeled COMMON

TABLE V-2
(Continued)

15 of 17

Variable Name	Description	Unit
SUBROUTINE RHYDRO		
GA	Internal variable, cross-sectional area of gutter when full	
GP	Internal variable, method perimeter of gutter when full	
GQ	Internal variable, flow in gutter when full	
GR	Internal variable, hydraulic radius of gutter when full	
GV	Internal variable, velocity in gutter when full	
G1	Read in value of bottom width of gutter or pipe diameter	ft
G2	Read in value of length of gutter	ft
G3	Read in value of invert slope	ft/ft
G4	Read in value of left-land side slope	ft/ft
G5	Read in value of right-hand side slope	ft/ft
G6	Read in value of Manning's coefficient	
G7	Read in value of depth of gutter when full	in
I	Bookkeeping integer	
INLETS	Integer counter, number of dummy gutters	
INUM	Bookkeeping integer	
J	Bookkeeping integer	
JG	Bookkeeping integer	
JK	Number of hyetograph	
JW	Bookkeeping integer	
K	Bookkeeping integer	
KL	Do loop counter	

TABLE V-2
(Continued)

14 of 17

Variable Name	Description	Unit
SUBROUTINE RECAP		
DELT	Integration time interval	sec
J	Bookkeeping integer	none
K	Bookkeeping integer	none
M	Bookkeeping integer	none
MAX	Bookkeeping integer	none
N	Bookkeeping integer	none
NLT	Bookkeeping integer	none
NPTS	Number of points to be plotted	none
NQS	Number of quality constituents	none
NRD	Bookkeeping integer	none
NREAD	Same as NSTEP	none
NSTEP	Number of time steps	none
NTIMEH	Hour of day of simulation (24-hour clock)	hr
NTX		
NTI		
TAREA	Total area	acres
TIMEM	Time of simulation (24-hour clock)	min
TZERO	Start time of hydrograph	sec

This subroutine uses the following common:

COMMON/TAPES/
Unlabeled COMMON

TABLE V-2
(Continued)

15 of 17

Variable Name	Description	Unit
SUBROUTINE RHYDRO		
GA	Internal variable, cross-sectional area of gutter when full	
GP	Internal variable, method perimeter of gutter when full	
GQ	Internal variable, flow in gutter when full	
GR	Internal variable, hydraulic radius of gutter when full	
GV	Internal variable, velocity in gutter when full	
G1	Read in value of bottom width of gutter or pipe diameter	ft
G2	Read in value of length of gutter	ft
G3	Read in value of invert slope	ft/ft
G4	Read in value of left-land side slope	ft/ft
G5	Read in value of right-hand side slope	ft/ft
G6	Read in value of Manning's coefficient	
G7	Read in value of depth of gutter when full	in
I	Bookkeeping integer	
INLETS	Integer counter, number of dummy gutters	
INUM	Bookkeeping integer	
J	Bookkeeping integer	
JG	Bookkeeping integer	
JK	Number of hyetograph	
JW	Bookkeeping integer	
K	Bookkeeping integer	
KL	Do loop counter	

TABLE V-2
(Continued)

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Variable Name	Description	Unit
MOD	Library function	
N	Bookkeeping integer	
NGOTO	Gutter number to which watershed drains	
NHR	Hour of start of storm	hr
NMN	Minutes of start of storm	min
NN	Bookkeeping integer	
NP	Read in value of NPG	
NPTS	Same as INLETS or NPRNT	
NQT	Same as NQS (COMMON/ABLK/)	
NSTP	Bookkeeping integer	
NTX	Tape unit identifier	
W1	Read in value of the average width of watershed	ft
W2	Read in value of the area of watershed	acre
W3	Read in value of the percent of imperviousness	%
W4	Read in value of the slope of watershed	ft/ft
W5	Resistance factor for impervious area	
W6	Resistance factor for pervious area	
W7	Retention storage depth for impervious area	in
W8	Retention storage depth for pervious area	in
W9	Read in value of maximum infiltration rate	in/hr
W10	Read in value of minimum infiltration rate	in/hr

TABLE V-2
(Continued)

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Variable Name	Description	Unit
W11	Read in value of decay rate of infiltration	1/sec
W12	Conversion factor, default value of 12	
This subroutine uses the following common:		
COMMON/ABLK/		
COMMON/INFIL/		
COMMON/NEW/		
COMMON/TAPES		
Unlabeled COMMON		
SUBROUTINE RUNOFF		
J	Bookkeeping integer	none
K	Bookkeeping integer	none
TFIX	Tape unit number	none
This subroutine uses the following common:		
COMMON/TAPES/		
Unlabeled COMMON		

TABLE V-3
TRANSPORT BLOCK VARIABLES

1 of 23

Variable Name	Description	Unit
COMMON/BD/		
ANORM	Matrix of normalized wet cross sectional area of conduit, based on shape and depth	
HRNORM	Matrix of normalized hydraulic radius of conduit, based on shape and depth	
TWNORM	Matrix of normalized conduit width at flow line, based on shape and depth	
	This common block is used by the following subroutines	
	INDATA	
	DEPTH	
	HYDRAD	
COMMON/BND/		
JFREE	Node for free outfall	None
JGATE	Node for non-weir tide gate	None
JTIDE	Not used at this time	None
NFREE	Number of free outfalls	None
NGATE	Number of non-weir tide gates	None
NTIDE	Indicator for outfall tide level control	None
	1. no water surface at outfall	
	2. outfall control water surface at constant elevation, A1	
	3. tide coefficients provided	
	4. program will compute tide coefficients	

TABLE V-3
(Continued)

2 of 23

Variable Name	Description	Unit
This common block is used by the following subroutines BOUND INDATA		
COMMON/CONTR/		
ALPHA	Title for printing	None
A1	Coefficients of the seven term equation for tidal input	Feet
A2		None
A3		None
A4		None
A5		None
A6		None
A7		None
DELTQ	Not used at this time	
DELT	Time interval of integration	Seconds
DELT2	One-half of DELT	Seconds
ICYC	Internal cycle counter	None
MJSW	Number of tape input hydrographs	None
NC	Number of conduits	None
NJ	Number of nodes	None
NJSW	Number of nodes for hydrograph input via cards	None

TABLE V-3
(Continued)

3 of 23

Variable Name	Description	Unit
NTC	Number of nodal links including internal links	None
NTCYC	Number of integration cycles	None
N5	Input unit number	None
N6	Output unit number	None
N21	Unit number for input tape from RUNOFF BLOCK	None
TIME	Time counter for hydrograph input	Seconds
TIME2	TIME - DELT2	Seconds
TZERO	Zero time for the analysis	Hours/Seconds
W	Fundamental frequency of daily tidal variation	Rad/Seconds

This common block is used by the following
subroutines

BOUND
INDATA
INFLOW
MAIN
OUTPUT
TIDCF

COMMON/ELEV/

IPLT	Plot control integer	None
ZCRN	Plot variable, highest crown elevation at a node	Feet
ZGRND	Plot variable, ground elevation	Feet
ZINVRT	Plot variable, node invert elevation	Feet

TABLE V-3
(Continued)

4 of 23

Variable Name	Description	Unit
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This common block is used by the following
subroutines
OUTPUT

COMMON/HYFLOW/

ISW	Hydrograph input node number from tape	None
JSW	Hydrograph input node number from cards	None
NINREC	Counter for hydrograph input from tape	None
NSTEPS	Number of input records on input hydrograph file	None
QCARD	Rate of inflow, from cards	cfs
QTAPE	Rate of inflow, from tape	cfs
TE	Time of inflow for card input	Hours/Seconds
TE0	Previous value of TE	Hours/Seconds
TIME0	TE0	Seconds
TP	TZERO	Seconds
T2	Time of inflow for tape input	
T20	Previous value of T2	Seconds
WATSH	Not used at this time	None

This common block is used by the following
subroutines
INDATA
INFLOW

TABLE V-3
(Continued)

5 of 23

Variable Name	Description	Unit
COMMON/JUNC/		
AS	Surface area of a node	Square Feet
GRELEV	Ground elevation at a node	Feet
JSKIP	Internal integer control, to skip node head computation	None
JUN	Node number	None
NCHAN	Conduits connecting to a node	None
QIN	Flow into a node from an outside source	cfs
QINST	Dry weather flow into a node from an outside source	cfs
QOU	Flow from a node	cfs
SUMAL	Sum of cross sectional area/length, for all pipes at node	Feet
Y	Depth of water at a node at full integration step	Feet
YT	Depth of water at a node at half integration step	Feet
Z	Elevation of node invert	Feet
ZCROWN	Elevation of uppermost conduit crown at a node	Feet

This common block is used by the following subroutines

BOUND
HEAD
INDATA
INFLOW
MAIN
OUTPUT

TABLE V-3
(Continued)

6 of 23

Variable Name	Description	Unit
COMMON/LAB/		
HORIZ	Horizontal label of curve	None
TITLE	Title printed out on curve	None
VERT	Vertical label	None
XLAB	Numerical scale labels for X	None
YLAB	Numerical scale labels for Y	None

This common is used by the following
subroutines

INDATA
OUTPUT

TABLE V-3
(Continued)

7 of 23

Variable Name	Description	Unit
COMMON/ORF/		
AORIF	Cross sectional area of orifice	Square Feet
CORIF	Orifice coefficient	Square Feet
LORIF	Internal number index	None
NORIF	Number of orifices	None
	This common is used by the following subroutines BOUND INDATA	
COMMON/OUT/		
CPRT	Conduit numbers for detailed printing	None
ICOL	Not used at this time	None
IDUM	Dummy array	None
INTER	Interval between print cycles	
IPRT	Not used at this time	
JPLT	Node numbers for plotting	None
JPRT	Node numbers for detailed printing	None
KPLT	Conduit numbers for plotting	None
LPLT	Number of conduits for detailed printing	None
LTIME	Counter for printed output	None
NHPRT	Number of nodes for detailed printing	None

TABLE V-3
(Continued)

8 of 23

Variable Name	Description	Unit
NPLT	Number of nodes to be plotted	None
NPRT	Not used at this time	None
NPTOT	Total number of plot data points	None
NQPRT	Number of conduits for detailed printing	None
NSTART	First cycle where saved printing array will begin	None
PRGEL	Print matrix, ground elevation	Feet
PRTH	Print matrix, water surface elevation	Feet
PRTQ	Print matrix, flow	cfs
PRTV	Print matrix, velocity	fps
PRTY	Print matrix, water depth at node	Feet
QPLT	Matrix of flow values	cfs
YPLT	Matrix of water surface elevations	Feet

This common is used by the following
subroutines

INDATA
MAIN
OUTPUT

COMMON/PIPE/

A	Full integration step wetted cross section	Square Feet
AFULL	Cross sectional area of conduit	Square Feet
AT	Half integration step wetted cross section	Square Feet

TABLE V-3
(Continued)

9 of 23

Variable Name	Description	Unit
DEEP	Vertical dimension of conduit	Feet
H	Internal depth variable	Feet
LEN	Conduit length	Feet
NCOND	Conduit number	None
NKCLASS	Conduit shape classification 1. circular 2. rectangular 3. horseshoe 4. eggshape 5. baskethandle 6. trapezoidal	None
NJUNC	Nodes at each end of conduit	None
Q	Flow in conduit at full integration step	cfs
QO	Saved flow values	cfs
QT	Flow in conduit at half integration step	cfs
RFULL	Hydraulic radius of conduit when full	Feet
ROUGH	Manning coefficient	
V	Velocity in conduit at the full integration step	fps
VT	Velocity in conduit at the half integration step	fps
WIDE	Width of conduit	Feet
ZP	Height of conduit invert above node invert	Feet

TABLE V-3
(Continued)

10 of 23

Variable Name	Description	Unit
------------------	-------------	------

This common block is used by the following
subroutines

BOUND
DEPTH
HEAD
HYDRAD
INDATA
MAIN
OUTPUT

COMMON/PUMP/

JPFUL	Internal integer switch for full wet well 0 = full 1 = not full	None
LPUMP	Internal pump linkage	None
NPUMP	Number of pumps	None
PRATE	Pumping rate	cfs
VRATE	Volume for changing pump rates	Cubic Feet
VWELL	Starting volume of pump wet well	Cubic Feet

This common is used by the following
subroutines

BOUND
INDATA

COMMON/QUAL/

INQUAL	Dummy variable for read purposes	None
--------	----------------------------------	------

This common block is used by the following
subroutines

INDATA
INFLOW

TABLE V-3
(Continued)

11 of 23

Variable Name	Description	Unit
COMMON/TIDE/		
AA	Tidal curve fit coefficients during least square process	None
SXX	Matrix used by best square process	None
SXY	Vector used by least square process	None
TT	Clock time of tidal condition	Hours/Seconds
XX	Vector used in least square tide fit	None
YY	Stage level of tidal input	Feet
This common is used by the following subroutines INDATA TIDCF		
COMMON/TRAP/		
SPHI	Side slope one side trapezoidal channel	Feet/Feet
STHETA	Side slope other side, trapezoidal channel	Feet/Feet
This common is used by the following subroutines HYDRAD INDATA DEPTH		
COMMON/TRNQAL/		
N22	Tape unit number of hydraulic output for QUALITY TRANSPORT BLOCK	None

TABLE V-3
(Continued)

12 of 23

Variable Name	Description	Unit
------------------	-------------	------

This common block is used by the following
subroutines
INDATA
MAIN

COMMON/WEIR

COEF	Coefficient of discharge for weir	None
COEFS	Coefficient of discharge for surcharged condition	None
KWEIR	Type of weir 1. transverse 2. transverse with tide gate 3. sideflow 4. sideflow with tide gate	None
LWEIR	Internal link number	None
NWEIR	Number of weirs	None
WLEN	Weir length	Feet
YCREST	Height of weir above invert	Feet
YTOP	Height to top of weir opening, above weir	Feet

This common is used by the following
subroutines
BOUND
INDATA

SUBROUTINE BOUND

AREA	Wetted cross sectional area of conduit	Square Feet
DIR	Internal check on flow direction	None

TABLE V-3
(Continued)

13 of 23

Variable Name	Description	Unit
HEADO	Internal variable for head at orifice	Feet
HEADW	Internal variable for head at weir	Feet
HLOSS	Loss of head, weir or tide gate	Feet
HRAD	Hydraulic radius	Feet
HS	Internal variable for head at submerged weir	Feet
HTIDE	Head resulting from tide computations	Feet
H1	Internal variable for nodal water surface elevation	Feet
H2	Internal variable for nodal water surface elevation	Feet
I	Bookkeeping integer	None
J	Bookkeeping integer	None
J1	Internal variable for node number	None
J2	Internal variable for node number	None
K	Bookkeeping integer	
KW	Internal variable, type of weir	None
LINK	Internal link number	None
N	Bookkeeping integer	None
POWER	Exponent for weir equation	None
QINJ	Summation of inflows to pump wet well	cfs
QORIF	Computed flow rate through orifice	cfs
QOUT	Computed pumped flow	cfs

TABLE V-3
(Continued)

14 of 23

Variable Name	Description	Unit
VEL	Velocity through a flap gate	fps
VEL1	Velocity through a tide gate	fps
VNEW	Pump wet well stored volume	Cubic Feet
V2	Reserved for use as approach velocity to weir. No used at this time	fps
WIDTH	Conduit width at computed depth	Feet
WK	Weir coefficient	None
Y1	Internal depth variables	Feet
Y2	Internal depth variables	Feet

This subroutine uses the following common:

/CONTR/
/JUNC/
/PIPE/
/ORF/
/WEIR/
/PUMP/
/BND/

SUBROUTINE DEPTH

AREA	Wetted cross sectional area of conduit	Square Feet
DELTA	Ratio of flow difference	None
HRAD	Hydraulic radius	Feet
I	Bookkeeping integer	None
QC	Internal variable for critical flow rate	cfs

TABLE V-3
(Continued)

15 of 23

Variable Name	Description	Unit
QCO	Internal variable for last computed critical flow rate	cfs
QNORM	Internal variable for normal flow rate	cfs
QNORMO	Internal variable for last computed normal flow rate	cfs

This subroutine uses the following common:
 /BD/
 /PIPE/
 /TRAP/

SUBROUTINE HEAD

AMID	Wetted cross sectional area of conduit at mid conduit	Square Feet
BMID	Width of water surface in conduit at mid conduit	Feet
BNH	Width of water surface in conduit at downstream end	Feet
BNL	Width of water surface in conduit at upstream end	Feet
RMID	Hydraulic radius at mid conduit	Feet
RNH	Hydraulic radius at downstream end	Feet
YC	Critical depth	Feet
YMID	Depth at mid conduit	Feet
YNH	Depth at downstream end	Feet

TABLE V-3
(Continued)

16 of 23

Variable Name	Description	Unit
YNL	Depth at upstream end	Feet
YNORM	Normal depth	Feet

This subroutine uses the following common:

/JUNC/
/PIPE/

SUBROUTINE HYDRAD

DELTA	Interpolation variable	None
DEPTR	Depth in conduit	Feet
DEPTT	Depth in conduit	Feet
FDEP	Difference between water surface depth and full conduit water surface depth	Feet
FDEPTH	Ratio of water surface depth to vertical conduit dimension	Feet/Feet
I	Bookkeeping integer	None
WETPER	Wetted perimeter of conduit	Feet

This subroutine uses the following common:

/BD/
/PIPE/
/TRAP/

SUBROUTINE INDATA

D1	Dummy variable	None
D2	Dummy variable	None

TABLE V-3
(Continued)

17 of 23

Variable Name	Description	Unit
D3	Dummy variable	None
I	Bookkeeping integer	None
II	Bookkeeping integer	None
J	Bookkeeping integer	None
JN	Internal print integer	None
JP	Internal integer, node number	None
J1	Internal integer, node number	None
J2	Internal integer, node number	None
K	Bookkeeping integer	None
KK	Bookkeeping integer	None
KLASS	Conduit shape classification	None
K0	Control integer on tide data	None
K1	Conduit number	None
L	Bookkeeping integer	None
LOC	Bookkeeping integer	None
NPT	Bookkeeping integer	None
NI	Bookkeeping integer	None
NAME	Tape element name	None
NCHTID	Print control on tide data	None

TABLE V-3
(Continued)

18 of 23

Variable Name	Description	Unit
NH	Node number, downstream node	None
NHR	Start time	Hours
NJ1	Control for internally generated nodes	None
NJ2	Control for internally generated nodes	None
NL	Node number, upstream node	None
NMN	Start time	Minutes
NTCYS	NTCYC plus one	None
NI	Bookkeeping integer	None
TEMP	Internal variable, conduit invert elevation	Feet
TPT	Time used in printing	Hours

This subroutine uses the following common:

/BD/
/CONTR/
/TRNQAL/
/JUNC/
/PIPE/
/ORF/
/WEIR/
/PUMP/
/BND/
/OUT/
/TIDE/
/HYFLOW/
/LAB/
/QUAL/

SUBROUTINE INFLOW

J	Bookkeeping integer	None
L	Bookkeeping integer	None

TABLE V-3
(Continued)

19 of 23

Variable Name	Description	Unit
Q1	Nodal inflow rates from external sources	cfs
Q2	Nodal inflow rates from external sources	cfs
SLOPE	Rate of change of inflow rates	Cu.Ft./sec.squared
TPT	Time	Hours

This subroutine uses the following common:

/CONTR/
/JUNC/
/QUAL/
/HYFLOW/

SUBROUTINE MAIN

AKON	Internal variable	None
ANH	Wetted cross sectional area of conduit at downstream end of conduit	Square Feet
ANL	Wetted cross sectional area of conduit at upstream end of conduit	Square Feet
DELQ1	Component of flow change during a time step	cfs
DELQ2	Component of flow change during a time step	cfs
DELQ3	Component of flow change during a time step	cfs
DELQ4	Component of flow change during a time step	cfs
HRAD	Hydraulic radius	Feet
I	Bookkeeping integer	None
J	Bookkeeping integer	None

TABLE V-3
(Continued)

20 of 23

Variable Name	Description	Unit
K	Bookkeeping integer	None
L	Bookkeeping integer	None
M	Bookkeeping integer	None
MCY	Bookkeeping integer	None
MCYY	Bookkeeping integer	None
MP	Bookkeeping integer	None
N	Bookkeeping integer	None
NDIM	Bookkeeping integer	None
NH	Internal downstream node number	None
ONEW	Last computed flow	cfs
QNORM	Normal flow in conduit	cfs
SUMQ	Summation of flow at node, using average conduit flow rates	cfs
SUMQS	Summation of flow at node, using last computed flow rates	cfs
YMAX	Height at node from invert to highest conduit crown	Feet

This subroutine used the following common:

/CONTR/
/TRNQAL/
/JUNC/
/PIPE/
/OUT/
/TRAP/

TABLE V-3
(Continued)

21 of 23

Variable Name	Description	Unit
SUBROUTINE OUTPUT		
I	Bookkeeping integer	None
IT	Bookkeeping integer	None
J	Bookkeeping integer	None
K	Bookkeeping integer	None
L	Bookkeeping integer	None
LT	Bookkeeping integer	None
LTIMEH	Time variable for printing	Hours
LTIMEM	Time variable for printing	Minutes
MJPRT	Node number for printing	None
N	Bookkeeping variable	None
NKON	Conduit number for printing	None
TIMEO	Start time of printing	Seconds

This subroutine uses the following common:

/CONTR/
/JUNC/
/PIPE/
/OUT/
/ELEV/
/LAB/

TABLE V-3
(Continued)

22 of 23

Variable Name	Description	Unit
SUBROUTINE TIDCF		
DEL	Internal variable	None
DELMAX	Maximum difference between the calculated and tidal stage input	Feet
DELTA	Maximum allowable difference between the calculated and input tidal stage	Feet
DIFF	Difference between the calculated and input tidal stage	Feet
FJ1	Internal variable	None
FJ3	Internal variable	None
I	Bookkeeping integer	None
IT	Bookkeeping integer	None
J	Bookkeeping integer	None
K	Bookkeeping integer	None
MAXIT	Maximum number of iterations	None
NJ2	Bookkeeping integer	None
NTT	Bookkeeping integer	None
PERIOD	Daily tidal cycle time in hours	Hours
RES	Accumulative difference between the calculated and input tidal stage	Feet

TABLE V-3
(Continued)

23 of 23

Variable Name	Description	Unit
SUM	Computed tidal stage	Feet

This subroutine uses the following common:
/CONTR/
/TIDE/

TABLE V-4
TRANSPORT QUALITY VARIABLES

1 of 11

Variable Name	Description	Unit
COMMON/BD/		
ANORM	Matrix of normalized wet cross sectional area of conduit, based on shape and depth	None
HRNORM	Matrix of normalized hydraulic radius of conduit, based on shape and depth	None
TWNORM	Matrix of normalized conduit width at flow line, based on shape and depth	None
This common is used by the following subroutines HYDRAD BLOCK DATA		
COMMON/CNTROL/		
ALPHA	Not used at present time	None
BETA	Description of Quality Transport simulation	None
DELT	Time interval of integration	Seconds
INTER	Number of time intervals between print data points	None
IQCYC	Bookkeeping integer, counter	None
NINREC	Bookkeeping integer on tape reads	None
NPRNT	Number of nodes for detailed printout	None
NOCYC	Number of integration cycles	None
NQUAL	Number of quality constituents	None
NSTART	Cycle for starting printout	None

TABLE V-4
(Continued)

2 of 11

Variable Name	Description	Unit
N21	Tape unit number, pollutograph data	None
N22	Tape unit number, hydraulics data	None
TE	Current time from hydraulic input tape	Seconds
TE0	Last current time from hydraulic input tape	Seconds
TIME	Time from start of simulation plus TZERO	Seconds
TIME0	Same as TE0	Seconds
TITLE	Description of results from Runoff Block input	None
TP	Same as TZERO	Seconds
TZERO	Start time of simulation	None
T2	Current time from pollutograph input tape	Seconds
T20	Last current time from pollutograph input tape	Seconds

This common is used by the following subroutines:

INDATA
INPUT
MAIN
OUTPUT

COMMON/COND/

AFULL	Cross sectional area of conduit	Square Feet
DEEP	Vertical dimension of conduit	Feet
LEN	Length of conduit	Feet
NC	Number of conduits	None

TABLE V-4
(Continued)

3 of 11

Variable Name	Description	Unit
NCOND	Conduit number	None
NJUNC	Nodes at each end of conduit	None
NKCLASS	Conduit shape classification	None
NTC	Number of links in system (NC plus internal)	None
Q	Flow in conduit	cfs
QAVE	Current flow in conduit	cfs
RFULL	Hydraulic radius of conduit when full	Feet
V	Velocity in conduit	fps
WIDE	Width of conduit	Feet

This common is used by the following subroutines

HYDRAD
INDATA
INPUT
MAIN
OUTPUT

COMMON/JUNCT/

C	Constituent concentration	mg/l
JSKIP	Control integer for pumps	None
JUN	Node number	None
MASSIN	Mass	mg/l-cu.ft.
NCHAN	Conduits connecting to a node	None
NJ	Number of nodes	None

TABLE V-4
(Continued)

4 of 11

Variable Name	Description	Unit
VOL	Current storage volume at node	Cu.Ft.
VOL0	Last current storage volume at node	Cu.Ft.
Y	Depth of water at node	Feet
YAVE	Current depth of water at node	Feet
This common is used by the following subroutines		
INDATA		
INPUT		
MAIN		
OUTPUT		

COMMON/OUT/

CONST	Constituent name	None
CPRNT	Computed constituent concentrations	mg/l
ICODE	Plot code indicator for constituents	
ICODL	Print code indicator for constituents	
JQPRT	Node numbers for detailed printout	None
LTIME	Counter for printed output	None
NPLTL	Lower limit of plot information in output storage arrays	
NPLTM	Upper limit of plot information output storage arrays	
QPRNT	Node flow unbalance	cfs

TABLE V-4
(Continued)

5 of 11

Variable Name	Description	Unit
This common is used by the following subroutines INDATA INPUT MAIN OUTPUT BLKD		
COMMON/PUMP/		
LPUMP	Internal pump linkage	None
NPUMP	Number of pumps	None
VPUMP	Pump wet well volume	Cu.Ft.
This common is used by the following subroutines INDATA INPUT MAIN OUTPUT		
COMMON/RUNOFF/		
ISW	Node numbers for pollutograph inputs	None
MJSW	Number of nodes for pollutograph inputs	None
NSTEPS	Number of data points on pollutograph input tape	None
WATSH	Watershed number	None
WDMDT	Mass input rate	grams/sec.
This common is used by the following subroutines INDATA INPUT MAIN OUTPUT		

TABLE V-4
(Continued)

-6 of 11

Variable Name	Description	Unit
------------------	-------------	------

COMMON/TRAP/

SPHI	Side slope of trapezoidal channel, one side	Feet/Feet
STHETA	Side slope of trapezoidal channel, other side	Feet/Feet

This common is used by the following
subroutines

HYDRAD

INDATA

SUBROUTINE HYDRAD

DELTA	Interpolation variable	None
DEPTR	Depth in conduit	Feet
DEPTT	Depth in conduit	Feet
FDEP	Difference between water surface depth and full conduit water surface depth	Feet
FDEPTH	Ratio of water surface depth to vertical conduit dimension	Feet/Feet
I	Bookkeeping integer	None
WETPER	Wetted perimeter of conduit	Feet

This subroutine uses the following common:

/BD/

/COND/

/TRAP/

TABLE V-4
(Continued)

7 of 11

Variable Name	Description	Unit
SUBROUTINE INDATA		
D1,D2,D3	Dummy variable	None
I	Bookkeeping integer	None
J	Bookkeeping integer	None
K	Bookkeeping integer	None
L	Bookkeeping integer	None
MIN	Start time	Minutes
N	Bookkeeping integer	None
NAMER	Not used at this time	None
NAMES	Not used at this time	None
NHR	Start time	Hours
NTCYC	Total number of time steps	None
TD	Dummy variable	None
TMAX	Maximum time simulated	Seconds
TMAXD	Maximum simulation time from hydraulic tape	Seconds
TMAXW	Maximum simulation time from pollutograph tape	Seconds
TTMAX	Minimum value between TMAXW and TMAXD	Seconds
TTEMP	Internal variable	

TABLE V-4
(Continued)

8 of 11

Variable Name	Description	Unit
------------------	-------------	------

This subroutine uses the following common:

/CNTRL/
/COND/
/JUNCT/
/OUT/
/PUMP/
/RUNOFF/
/TRAP/

SUBROUTINE INPUT

I	Bookkeeping integer	None
J	Bookkeeping integer	None
L	Bookkeeping integer	None
N	Bookkeeping integer	None
Q1	Current flow rate in conduit	cfs
Q2	Last current flow rate in conduit	cfs
SLOPEQ	Rate of change of flow	cfs/sec
SLOPEY	Rate of change of head at node	ft/sec
TD	Dummy variable	
W1	Current mass input rate	mg/l-cu.ft.
W2	Last current mass input rate	mg/l-cu.ft.
Y1	Current head	Feet
Y2	Last current head	Feet

TABLE V-4
(Continued)

9 of 11

Variable Name	Description	Unit
<p>This subroutine uses the following common:</p> <p>/CNTROL/ /COND/ /JUNCT/ /OUT/ /PUMP/ /RUNOFF/</p>		
SUBROUTINE MAIN		
A1	Wetted cross sectional area of conduit, upstream end	Square Feet
A2	Wetted cross sectional area of conduit, downstream end	Square Feet
GRAD	Concentration gradient in conduit	mg/l-ft.
HRAD	Hydraulic radius	Feet
I	Bookkeeping integer	None
II	Bookkeeping integer	None
J	Bookkeeping integer	None
JFROM	Upstream node number	None
JPUMP	Pump node number	None
J1	Upstream node number	
J2	Downstream node number	
K	Bookkeeping integer	None
L	Bookkeeping integer	None
MCY	Bookkeeping integer	None

TABLE V-4
(Continued)

10 of 11

Variable Name	Description	Unit
N	Bookkeeping integer	None
N1	Bookkeeping integer	None
SUMQ	Sum of flows at a node	cfs
VPUMPO	Pump wet well volume	Cubic Feet

This subroutine uses the following common:

/CNTRL/
/COND/
/JUNCT/
/OUT/
/PUMP/
/RUNOFF/

SUBROUTINE OUTPUT

I	Bookkeeping integer	None
IT	Bookkeeping integer	None
J	Subscript integer	None
KC	Bookkeeping integer	None
L	Bookkeeping integer	None
LL	Bookkeeping integer	None
LT	Bookkeeping integer	None
LTIMEH	Time for print purposes	Hours
LTIMEM	Time for print purposes	Minutes

TABLE V-4
(Continued)

11 of 11

Variable Name	Description	Unit
------------------	-------------	------

This subroutine uses the following common:

/CNTROL/
/COND/
/JUNCT/
/OUT/
/PUMP/
/RUNOFF/

CHAPTER VI

CRITERIA APPLICABLE TO THE RIBCO STUDY AREA

INTRODUCTION

The urban stormwater models will be used by counties, municipalities, local agencies, and consultants as tools for evaluating existing and future drainage systems, and for comparing alternative courses of action. Presented in this section are specific rainfall, infiltration, and receiving water criteria that are representative of the Green and Cedar River Basins and should be used as input to the models.

In addition to the above criteria, recommendations are presented for the planning of storm drainage facilities. These recommendations are based upon the design standards presently being followed by most of the governmental agencies within the RIBCO study area.

Both the criteria and the recommendations were reviewed and approved by the Urban Runoff and Basin Drainage Technical Review Subcommittee and by RIBCO.

RAINFALL

The time distribution of rainfall in a storm is of considerable importance in calculating the resulting runoff. This is especially true when utilizing the urban stormwater models to simulate runoff.

Rainfall records were collected and analyzed for the stations located in and adjacent to the Cedar and Green River Basins. The results indicate that a generalized rainfall rate versus time relationship is applicable to all lands within the Basins at elevations below 500 feet that are located west of a north-south line through Issaquah and Enumclaw.

The criteria presented herein are not applicable to lands above elevation 500 feet, as a large portion of the precipitation in the upper areas of the Cedar River and Green River Basins is in the form of snow, and frozen ground conditons are prevalent.

The planning of storm drainage facilities, as discussed in subsequent pages, is based upon the runoff resulting from the rainfall having a 10-year recurrence interval. Therefore, rainfall for the 10-year recurrence interval is as follows:

<u>Duration</u>	<u>Total Rainfall (inches)</u>	
	<u>Within the City of Seattle</u>	<u>Remainder of Study Area</u>
10 minutes	0.27	0.33
20 minutes	0.36	0.44
30 minutes	0.41	0.52
1 hour	0.55	0.67
2 hours	0.74	0.88
4 hours	1.00	1.16
6 hours	1.20	1.40
12 hours	1.78	1.98
24 hours	2.40	2.80

For all sub-basins within the study area a four-hour duration storm will generate the highest, or almost the highest, peak rate of runoff. It is recommended, therefore, that a four-hour duration storm be used in the computer model. If desired, larger or shorter duration storms can be used and the results compared against the results of a four-hour storm.

U.S. Weather Bureau technical papers can be used for obtaining rainfalls with other than a 10-year recurrence interval. The rainfall distribution versus time relationship for storms with greater recurrence intervals will be approximately the same distribution as that listed above for the 10-year recurrence interval.

INFILTRATION

The surface infiltration rates of the soils within the Green and Cedar River Basins, except forested lands at high elevations, have been measured by the USDA Soil Conservation Service and are appropriate for use in the stormwater models.

The Soil Conservation Service infiltration rates, high, medium or low, for each soil type, have been compiled on maps at a scale of 1" = 2000 ft. by the Puget Sound Governmental Conference. Both initial (maximum) infiltration rate and base (minimum) infiltration rate are used in the computer model. The rate of decay is 0.00115 for all soil types. Infiltration of rainfall on impervious areas is to be considered negligible.

Infiltration rates by land use classification is as follows:

<u>Land Use</u>	<u>Intake Rate from Maps</u>	<u>(Inches per Hour)</u>	
		<u>Maximum</u>	<u>Minimum</u>
Parks/Dedicated Open Space	High	3.0	0.7
Agriculture	Medium	2.5	0.4
Unused Land	Low	2.0	0.2
Single-Family Residential	High	2.5	0.4
	Medium	2.0	0.2
	Low	2.0	0.2
Multi-Family Residential	High	2.0	0.2
Commercial/Services	Medium	2.0	0.2
Government and Education	Low	2.0	0.2
Industrial			

As the land use becomes more intense intake rates are reduced from the natural rates (i.e. those indicated for Parks/Dedicated Open Space, Agriculture, Unused Land). This reduction in intake rates is due to a greater compaction of the surface soils as a result of clearing and grading operations associated with the construction of homes, stores, industrial facilities, etc.

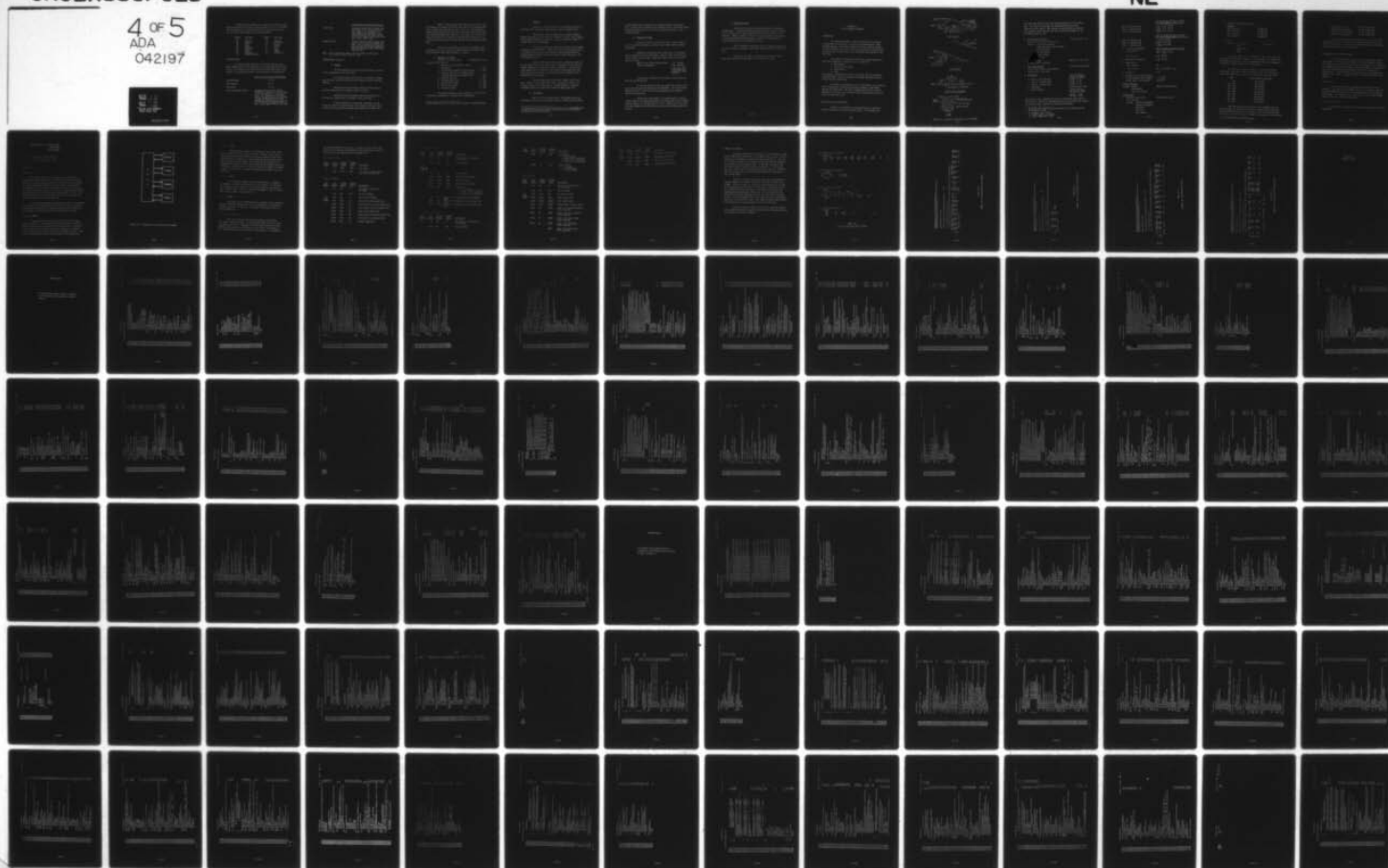
AD-A042 197

KCM-WRE/YTO SEATTLE WASH
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74

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In addition to the intake rate, certain soils within the study area are limited as to the total volume of water that can be infiltrated. The following soils, as identified by the Soil Conservation Service, have a maximum to two inches of infiltration capacity:

<u>Symbol</u>	<u>Soil Type</u>	<u>Symbol</u>	<u>Soil Type</u>
Br	Briscot	Tu	Tukwila
Nk	Nooksack	Bh	Bellingham
No	Norma	Bu	Buckley
Or	Orcas	Os	Oridia
Sh	Sammamish	O	Ovall
Sk	Seattle	Pu	Puget
Sm	Shalcar	Su	Sultan
So	Snohomish	Wo	Woodinville
Sr	Snohomish (thick)		

RECEIVING WATERS

All storm drainage facilities in the Green and Cedar River Basins empty into one of the following six receiving water bodies. Therefore, all facilities must be able to discharge storm runoff against the natural, or man-controlled, water surface elevations indicated herein.

Water Surface Elevations (USGS datum)

Lake Washington	15.0 ft.
Lake Sammamish	32.5 ft.
Puget Sound	8.2 ft.

Green River/Duwamish River

The water surface profile labeled "12,000 cfs at Auburn" on 28 x 40" plan and profile sheets 2 of 12 through 12 of 12. This represents a recurrence interval of approximately 300 years and includes SCS pumping system. These drawings were prepared by the Corps and are entitled Green & Duwamish Rivers, Wash., Survey Report Profiles, May 1968.

Water Surface Elevations (USGS datum)

Cedar River

The water surface profile labeled "100 year flood" on 28" x 40" plan and profile sheets 1 of 7 through 7 of 7. These drawings were prepared by the Corps and are entitled "Water Surface Profiles for Flows Limited to the Floodway," dated 1 August 1970.

Sammamish River

The water surface profile labeled "100 year" on 11" x 22" profile sheets, two total. These drawings were prepared by the Corps and are entitled "Sammamish River Profiles Mile 0.00 to Mile 14.95," dated May 1974.

NOTE: Corps of Engineers' datum is 6.33 ft. below the USGS datum.
(e.g. 12.00 ft. Corps = 5.67 ft. USGS)

STORM DRAINAGE FACILITIES

A. General

All storm drainage facilities should be planned to conform to the recommendations set forth herein.

All storm drainage facilities shall be planned to accommodate the runoff resulting from the rainfall having a 10-year recurrence interval.

Watercourses and storm sewers having a drainage area of over four square miles are classed as major facilities.

Watercourses and storm sewers having a drainage area of less than four square miles are classed as minor facilities.

A given watercourse or storm sewer, therefore, will be classed as minor in its upper reaches, then changed to the major classification at a point where the drainage area exceeds four square miles.

Depth of flow in gutters shall not exceed 0.4 feet. Roadside ditches* are allowed, except that they shall not be used where the flow is greater than that which could be carried in a standard gutter flowing 0.4 feet deep on the same slope as the road profile slope. Where the discharge exceeds gutter capacity, a storm sewer shall be provided. Roadside ditches shall be planned so that the water surface will be at or below the outside edge of the road shoulder and below adjacent ground level.

Insofar as is practicable, catch basins, manholes, inlet structures, etc., shall conform to standard plans of the public agency with jurisdiction where the improvement is located.

B. Manning's "n" Values

Manning's "n" values (coefficient of roughness) for planning shall be as follows:

- | | |
|---|----------|
| 1. Concrete, steel troweled or smooth-form finish | n = .013 |
| 2. Concrete pipe, precast or cast-in-place | n = .014 |
| 3. Concrete, wood flat, or broomed finish; including pneumatically applied mortar | n = .015 |
| 4. Asphaltic concrete | n = .017 |
| 5. Corrugated metal pipe | n = .024 |
| 6. Sack concrete riprap | n = .030 |
| 7. Grouted rock riprap | n = .040 |
| 8. Loose rock riprap | n = .050 |

For grassed channels, natural channels, or materials not covered above, appropriate "n" values shall be determined.

*Stream channels parallel to roads are not classed as roadside ditches.

C. Channels*

Channels, as referred to herein, exclude the main stems of the Cedar River, Green River/Duwamish River, and the Sammamish River.

Major channels shall be planned with a minimum freeboard between the water surface and the top of bank of 1.0 foot. Minor channels may be planned without any freeboard. The use of levees for control of channel flow will be discouraged.

For natural watercourses flow may be allowed in the floodway area above the defined banks. However, that flow will be contained within a defined overflow area, and freeboard as specified above shall be provided between the water surface and adjacent ground elevation or finished grade elevation.

Culverts along major channels shall be planned to flow full, but not under pressure, and shall cause no encroachment on the specified minimum freeboard in the upstream channel or waterway. Culverts along minor channels may be planned for full capacity and pressure flow, but shall cause no encroachment on the specified minimum freeboard in the upstream channel or waterway.

Minimum bottom width of artificial channels shall be 2.0 feet. Channels may be lined with concrete, grouted rock riprap, sack concrete riprap, or air-blown mortar. Grassed channels or loose-rock riprapped channels shall have side slopes not steeper than 2 to 1.

D. Storm Sewers

Major facilities placed within a storm sewer system shall be planned to flow full, but not under pressure. Minor facilities placed

*In conjunction with the criteria set forth herein, it is recommended that all local agencies require building sites to be one to two feet above planned water surfaces elevations.

in storm sewers may be planned for full conduit capacity and pressure flow. At inlets and non-pressure type manholes within a storm sewer system, the water surface shall be 1.0 foot or more below the gutter or inlet surface elevation.

E. Storage Facilities

Storage facilities can be natural lakes or ponds, they can be all or partially man-made, and they can be located either offstream or onstream.

Embankments and holding ponds located near or on channels must be specifically sited and designed. However, small-sized (100 acre-feet or smaller) holding ponds, other than natural areas, will be considered as follows:

Depth of water above adjacent ground:	8 ft. maximum
Perimeter embankment:	12 ft. top width
	3 horz. to 1 vert. side slopes constructed of earth material

The perimeter embankments shall be grass lined on both the pond side and the outside.

All holding ponds shall have an uncontrolled overpour spillway to keep the pond from overtopping the embankment. The top of the embankment shall be 1.5 feet above the maximum water surface elevation within the holding pond.

Outlets shall be provided in all holding ponds to release incoming flows to the downstream channel at retarded rates, but not greater than the capacity of the downstream facilities. Outlets also can be used to release temporarily stored waters, and to allow the holding pond to be emptied.

F. Pumping Facilities

Pumping facilities may be used with detention and retention storage ponds. In planning retention storage facilities, the use of gravity flow to release as much water as possible after the storm passes is most desirable. However, pumping facilities are usually located in low portions of levee-protected areas where pumping is required to lift the water to higher elevations such as discharging to a river.

After a retention storage pond volume is selected, pumps shall be sized to pump all subsequent inflow water from the pond to the receiving area.

Pumps shall be capable of pumping against the most severe static head (usually low pond water level to peak river stage).

CHAPTER VII

COST DETERMINATION PROGRAM

INTRODUCTION

This chapter describes a computer program which is designed to facilitate the calculation of various costs associated with urban drainage problems. The primary function of the cost analysis program is to calculate preliminary capital costs of construction of storm drainage facilities and the generalized cost of purchasing land required for the facilities.

The program is formulated to include four broad categories of facilities construction (see Figure VII-1). These are:

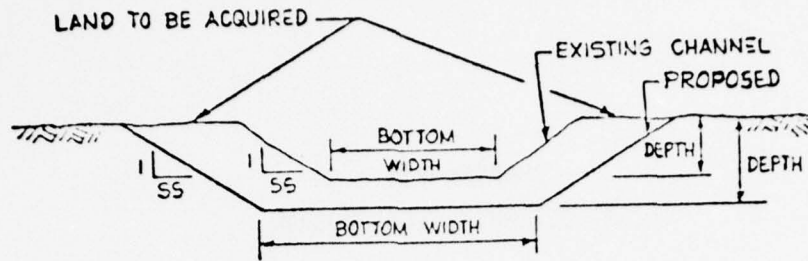
1. Open channels
2. Pipe inlets and outlets
3. Holding ponds
4. Pipes

This program is intended to be used in conjunction with the stormwater simulation models, and can be employed to estimate preliminary costs of various drainage alternatives.

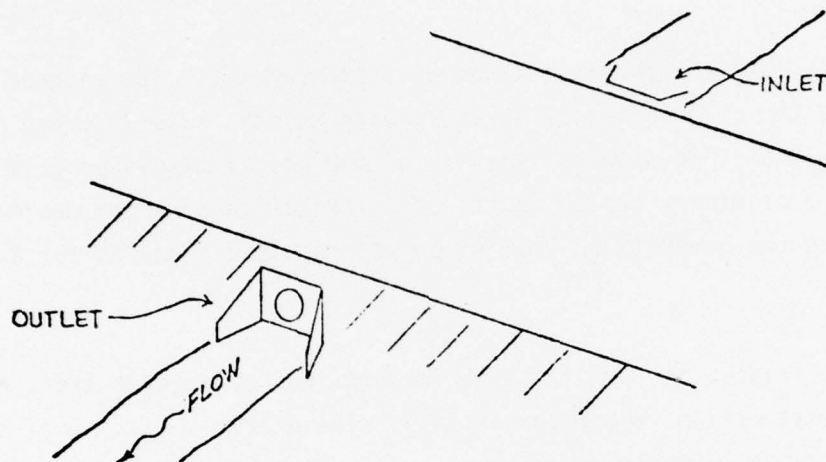
The program was developed for use in preliminary cost estimating. Several mathematical computations have been shortened to approximate versions for convenience. The total estimated capital cost is heavily dependent upon the unit costs and these formula modifications have little effect upon the total costs.

UNIT COSTS FOR THE SEATTLE AREA

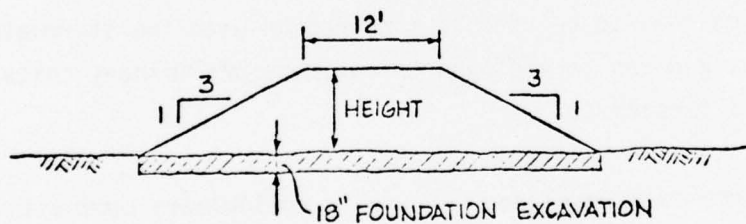
The model is programmed to calculate construction quantities and then to apply unit costs to determine totals. The following unit



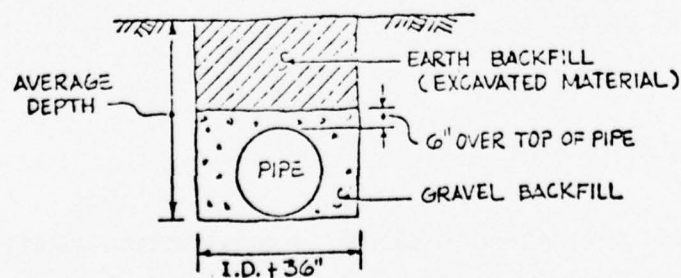
OPEN CHANNELS



INLETS/OUTLETS



HOLDING POND EMBANKMENTS



PIPES

FIGURE VII-1 CONCEPTUAL DEFINITIONS OF COST ELEMENTS

costs have been compiled from actual construction costs in the Seattle area. The costs are based upon the Engineering News Record (ENR) construction cost index of 1450, because the basic portions of the program related to pipes and unit costs were originally developed for use on a METRO project in 1971.

1. Open Channel Excavation \$3.30 per cubic yard
 (off-site haul of less than one mile)
 includes: clearing and grubbing
 coffer dam and/or diversion pipe
 fish protection
 erosion control
 final trimming
 clean-up
2. Pipe Lining \$100.00 per cubic yard
 4 inches thick, reinforced
3. Loose Rock Rip-Rap \$12.50 per square yard^{1.}
 8 to 15 inch diameter rock, placed an
 average of 12 inches thick
4. Pipe Costs^{2.}

	Cost in dollars per foot of length
A. Class III Concrete Pipe	0.0796 D 1.50
Class IV Concrete Pipe	0.0736 D 1.55
Class V Concrete Pipe	0.0728 D 1.58
B. Excavation	\$2.50 per cubic yard
C. Gravel backfill	Cost in dollars per foot of length

$$\frac{4.0}{27} \left(\frac{D}{12} + 3 \right) \frac{D}{12}$$

Combining A, B and C together with cost of installation, earth backfill, catch basins or manholes at 500 feet spacing, site restoration and clean-up the following total installed cost formulas were derived:

1. Based upon small quantities placed primarily at isolated locations along natural streams.
2. D = Diameters are in inches
 B = Backfill depths are in feet
 Z = Trench depths are in feet

	Cost in dollars per foot of length for trench depths 12 feet or less
Class III Concrete Pipe	0.431 D ^{1.15} Z ^{0.118}
Class IV Concrete Pipe	0.492 D ^{1.15} Z ^{0.118}
Class V Concrete Pipe	0.586 D ^{1.15} Z ^{0.118}
	Cost in dollars per foot of length for trench depths greater than 12 feet
Class III Concrete Pipe	0.181 D ^{1.15} Z ^{0.45}
Class IV Concrete Pipe	0.207 D ^{1.15} Z ^{0.45}
Class V Concrete Pipe	0.246 D ^{1.15} Z ^{0.45}
D. Imported Earth Backfill	Cost in dollars per foot of length
for Z ≤ 12 ft.	$(\frac{D}{12} + 3) \frac{B}{27} (1.75)$
for Z > 12 ft.	0.03 D ^{0.78} B
E. Imported Gravel Backfill	0.08 D ^{0.78} B
F. Sheet Piling	
for Z ≤ 10 ft.	20
for Z > 10 ft.	20 + (.70 Z ^{.43})(Z - 10)
G. Dewatering	0.73
H. Pavement and Utility Restoration	
27 inch diameter pipe or smaller	1.11 D ^{0.23}
greater than 27 inch diameter	0.32 D ^{0.62}
5. <u>Inlets and Outlets</u>	
includes: headwall	\$40 per inch of pipe dia.
two wingwalls	
loose rock rip-rap	
6. <u>Holding Ponds</u>	
A. Embankment construction	\$2.90 per cubic yard
(local material)	
includes: clearing and grubbing	
foundation excavation	
compaction	
final trim	
grass seeding	

B. Spillway (uncontrolled overpour)

Capacity

100 cfs or less	\$4,000 each
110 to 400 cfs	\$8,000 each
450 to 1,000 cfs	\$12,000 each
over 1,000 cfs	\$16,000 each

C. Outlet

includes: 24 inch pipe	\$4,000 each
inlet	
control gate	
outlet	

The program applies the foregoing unit costs to the specified quantities and calculates a subtotal. To this subtotal the program adds 50 percent for contractor's profit, engineering, legal, and contingencies to arrive at a total capital cost of construction.

All unit costs, except land costs, are based upon the ENR construction cost index of 1450. Adjustments to past or future years can be made using past or projected cost indices as summarized below.

<u>Date</u>	<u>ENR Construction Cost Index</u>
1913	100 National
Dec. 1950	560 Seattle
Dec. 1955	690 Seattle
Dec. 1960	850 Seattle
Dec. 1965	1030 Seattle
Dec. 1970	1410 Seattle
Mar. 1971	1450 Seattle
June 1973	1760 Seattle
Dec. 1973	1840 Seattle

Land costs represent an average of costs throughout the study area to purchase the land, plus 50 percent for severance and acquisition. These are based upon actual fall 1973 costs¹ within the Green and Cedar River Basins. The unit land costs included in the program are the following:

1. Data from METRO's right-of-way records.

Agricultural, vacant	\$0.12 per square foot
Single family residential	1.05 per square foot
Multiple family residential	1.65 per square foot
Commercial and industrial	2.25 per square foot

It should be noted that these costs are not based upon the ENR construction cost index, and will not increase or decrease in the same manner as that index. If new land costs are deemed necessary the computer program will need appropriate modification.

DESCRIPTION OF THE COMPUTER PROGRAM

This section describes the logic and input preparation for the COST program. A functional description of the various computer routines plus a detailed explanation of the data input is provided. This explanation is intended to provide the user with a basic understanding of the program, but is not intended to provide the detail necessary to make program modifications. If modifications are desired the user should contact the authors of this report. A program listing is supplied at the back of this document.

PROGRAM LANGUAGE

This model was originally programmed for the UNIVAC 1108 in FORTRAN V. This version of the FORTRAN compiler is essentially compatible with IBM FORTRAN level G and versions of the model have been executed on IBM equipment. This FORTRAN is also compatible with the Extended FORTRAN compiler used on CDC 6000 series equipment.

OPERATING REQUIREMENTS

This program is executed as an in-core unit, and has the following requirements:

High speed core \approx 14,200₈ words
 \approx 6,000₁₀ words
 \approx 24,000₁₀ bytes

1 card reader (logical unit 5)
1 line printer (logical unit 6)

PROGRAM LOGIC

Program Cost

The flow of logic for the cost program is indicated in Figure VII-2. Program execution is initiated in the executive routine, COST, which reads and prints an overall run comment card, the specified ENR index, and then information which directs control to each of the four component cost subroutines. A grand total for all facilities will be accumulated for the cost run until a card is encountered which directs the program to print the total and reset the grand total to zero. This feature enables the user to make several grand total calculations for different problems in the same computer run.

As far as the COST program is concerned the order of calculation is unimportant. The program simply accepts the input data in the order presented and then processes it through the appropriate subroutine in a serial fashion. Any subroutine can be called any number of times.

Subroutine CHANNEL

Subroutine CHANNEL computes the costs associated with open channel construction. The routine first computes the total excavation and land quantities and then applies the unit cost factors. Concrete or rip-rap lining can be included in the cost calculation on an optional basis. A summary of costs is printed each time CHANNEL is called. There is no limit on how many channels may be included in one computer run.

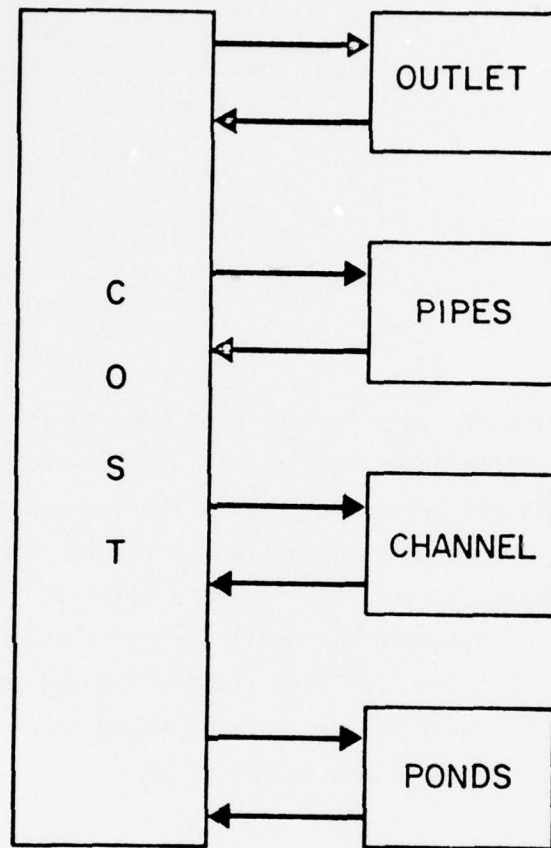


FIGURE VII-2 PROGRAM LOGIC COST DETERMINATION PROGRAM

Subroutine PIPES

Subroutine PIPES computes the installation cost of pipe excavation and placement from the given unit costs. The total capital costs is obtained from the sum of the costs of the pipe, excavation, installation, gravel backfill to a depth of six inches above the top of the pipe, catch basins or manholes, and cleanup. Options are imported earth backfill, imported gravel backfill, sheet piling, dewatering, and pavement and utility restoration. No land costs are included as pipes are assumed to be located in public rights-of-way. A maximum of 100 pipes may be costed in any computer run.

Subroutine OUTLET

This subroutine computes the total capital cost of a headwall, two wingwalls, and rock rip-rap for an inlet or an outlet. No land costs are included as inlets and outlets to pipes are assumed to be located in public rights-of-way. There is no limit to the number of inlets or outlets which may be included in any computer run.

Subroutine PONDS

The capital cost of holding ponds is calculated in this subroutine. The cost calculation includes the cost of the embankment, an uncontrolled spillway, an outlet, and land cost. Any number of ponds may be input to a single computer run.

CARD INPUT SPECIFICATIONS

This section outlines the exact specifications for defining card input to the COST program. In the job stream cards (1) and (2) below, must appear in each run. Subsequent to that the specifications for ponds, channels, inlets/outlets or pipes may be in any order or not included at all. Whenever the work PRINT, beginning in card column 6, is encountered,

the current grand total for the run is printed, set back to zero, and control sent to the top of the program to read new entries on cards (1) and (2) and to loop through the entire sequence again.

Input for all Runs

<u>Card Number</u>	<u>Card Column</u>	<u>FORTRAN Format</u>	<u>FORTRAN Name</u>	<u>Description</u>
1	1- 8	20A4	TITLE	Any comment
2	1-10	F10.0	ENR	The Engineering News Record Cost Index for this run

Input for Channels

<u>Card Number</u>	<u>Card Column</u>	<u>FORTRAN Format</u>	<u>FORTRAN Name</u>	<u>Description</u>
1	1- 5	I5	N	The number of channels to be costed
	7-14	A4	IDX	The word CHANNELS
N more cards	1- 8	I8	J	The channel ID number
	9-16	F8.0	D1	Depth of existing channel (ft)
	17-24	F8.0	B1	Bottom width of existing channel (ft)
	25-32	F8.0	S1	Side slope of existing channel (H/V)
	33-40	F8.0	D2	Depth of new channel (ft)
	41-48	F8.0	B2	Bottom width of proposed channel (ft)
	49-56	F8.0	S2	Side slope of new channel (H/V)
	57-64	F8.0	XL	Channel length (ft)

Input for Holding Ponds

<u>Card Number</u>	<u>Card Column</u>	<u>FORTRAN Format</u>	<u>FORTRAN Name</u>	<u>Description</u>
1	1- 5	I5	N	The number of holding ponds to be costed
	7-14	A4	IDX	The word PONDS
N groups of cards A-B				
A	1- 5	I5	J	Pond ID number
	6-15	F10.0	SVOL	Pond volume (acre-feet)
	16-25	F10.0	AREA	Pond area (acres)
	26-35	F10.0	SPILL	Spillway capacity (cfs)
	36-45	I10	ICLS	Land class: 1 = Ag. or vacant 2 = Single family residential 3 = Multi-family residential 4 = Commercial and Industrial
B	1- 5	I5	repeat group 1 to 14 times on each card	IR Embankment section ID number
	6-10	F5.0	H	Embankment section height (ft)
	11-20	F10.0	XL	Embankment section length (ft)

Input for Inlets/Outlets

<u>Card Number</u>	<u>Card Column</u>	<u>FORTRAN Format</u>	<u>FORTRAN Name</u>	<u>Description</u>
1	1- 5	I5	N	The number of INLETS/OUTLETS to be costed
	7-14	A4	IDX	The word OUTLET

<u>Card Number</u>	<u>Card Column</u>	<u>FORTRAN Format</u>	<u>FORTRAN Name</u>	<u>Description</u>
	65-72	I8	ICLS	Land category: 1 = Ag. or vacant 2 = Single family residential 3 = Multi-family residential 4 = Commercial and Industrial
	73-80	I8	ILYN	Channel lining: 0 = no lining 1 = concrete lining 2 = rip-rap lining

Input for Pipes

<u>Card Number</u>	<u>Card Column</u>	<u>FORTRAN Format</u>	<u>FORTRAN Name</u>	<u>Description</u>
1	1- 5	I5	N	The number of pipes to be costed (≤ 100)
	7-14	A4	IDX	The word PIPES
N more cards	1-10	I10	NO	The pipe ID number
	11-20	F10.0	DIA	Pipe diameter (in)
	21-30	F10.0	LENGTH	Pipe length (feet)
	31-40	F10.0	DEPTH	Average depth to invert (ft)
	41-45	I5	INDEX	Enter 1 for imported backfill; blank otherwise
	46-50	I5	INDEX	Enter 1 for gravel backfill; blank otherwise
	51-55	I5	INDEX	Enter 1 for sheet piling, blank otherwise
	56-60	I5	INDEX	Enter 1 for dewatering, blank otherwise
			INDEX	Enter 1 for restoration, blank otherwise

<u>Card Number</u>	<u>Card Column</u>	<u>FORTRAN Format</u>	<u>FORTRAN Name</u>	<u>Description</u>
N more cards	1- 5	I5	NO	The INLET/OUTLET ID number
	6-15	F10.0	DEPTH	The depth of fill (ft)
	16-25	F10.0	DIA	The pipe diameter (in)
	26-37	3A4	NAME	The word INLET or OUTLET

EXAMPLE CALCULATIONS

An example calculation for each type of cost calculation, pipes, ponds, channels and inlets/outlets is included in this section. The card data used in the examples is listed and shown at Table VII-1. Note that all the data is entered in one computer run and the PRINT card separates the calculation of the separate items. If the PRINT card was omitted the comment and ENR index cards would be deleted for all cases except the first, and the run results would be essentially the same. The PRINT card was included here to allow a different comment to be printed for each example output.

Table VII-2 shows the costs associated with the enlargement of two open channels. No channel lining costs have been included in this example. Table VII-3 shows the results for the construction of an inlet on a 24-inch pipe and an outlet on a 48-inch pipe. There are no options in the INLET/OUTLET cost calculation. The costs associated with two holding ponds are displayed in Table VII-4. As can be seen the first pond has two different embankment sections while the second is defined by three. The final example, Table VII-5, shows the cost of placing two pipes, one 42-inch and one 30-inch. This example includes gravel backfill and the option for including pavement and utility restoration.

These four examples, Tables VII-2 to VII-5, cover the complete range of the COST program's capability and should be thoroughly understood by any potential user of the program.

EXAMPLE PROBLEM.....CHANNELS

```

1763
2 CHANNELS
94      5.0      6.0      1.0      5.0      6.5      2.0      530      2      0
103     3.0      2.5      3.0      3.5     12.0      2.0     1030      2      0
PRINT
    
```

EXAMPLE PROBLEM.....OUTLETS

```

1763
2 OUTLETS
27      10      24 INLET
999     15      48 OUTLET
PRINT
    
```

EXAMPLE PROBLEM.....PONDS

```

1763
2 PONDS
30      60      9.0      200      2
1  5.0      6.0      2  8.0      1400
61      150     15.0     500      4
1  7.0      4.0      2  3.0      800      3 10.0      250
PRINT
    
```

EXAMPLE PROBLEM.....PIPES

```

1763
2 PIPES
127      42      900      7      1
128      34     1300      6      1
PRINT
    
```

TABLE VII-1
EXAMPLE PROBLEM CARD INPUT LISTING

PIPE, CHANNEL, OUTLET AND POND COST ANALYSIS PROGRAM.....
 PROCEDURES DEVELOPED FOR COST ANALYSIS OF DRAINAGE PROBLEMS NEAR SEATTLE.....
 COST PROGRAM WRITTEN FOR THE RISCO PROJECT.....

EXAMPLE PROBLEM.....CHANNELS

COSTS ARE BASED UPON AN ENR CONSTRUCTION COST INDEX OF 1763.

..... COST SUMMARY FOR OPEN CHANNELS

..... SUBTOTAL COST INCLUDES 50% FOR CONTRACTORS PROFIT, ENGINEERING, LEGAL, AND CONTINGENCIES

NO	EXISTING CHANNEL...				ENLARGED CHANNEL...				TOTAL TYPE		NET EXCAV VOLUME (CY)	LAND AREA (ACRES)	EXCAV COST (K\$)	CONCRT LINING COST (K\$)	RIPRAP LINING COST (K\$)	SUBTOT COST (K\$)	LAND COST (K\$)	TOTAL COST (K\$)	
	DEPTH (FT)	BOTTOM WIDTH (FT)	SIDE SLOPE (H/V)	DEPTH (FT)	BOTTOM WIDTH (FT)	SIDE SLOPE (H/V)	LENGTH (FT)	TYPE	LINE										
94	5.0	6.0	1.0	5.0	6.0	2.0	500.	2	0	0	509.3	.1	2.0	.0	.0	3.1	5.5	8.6	
103	3.0	2.5	3.0	3.5	12.0	2.0	1000.	2	0	0	1185.2	.1	4.8	.0	.0	7.1	5.8	12.9	
TOTALS FOR 2 CHANNELS											1694.4	.2	6.8	.0	.0	.0	10.2	11.3	21.5

TABLE VII-2
 EXAMPLE COST CALCULATION FOR OPEN CHANNELS

PIPE, CHANNEL, OUTLET AND POND COST ANALYSIS PROGRAM.....
 PROCEDURES DEVELOPED FOR COST ANALYSIS OF DRAINAGE PROBLEMS NEAR SEATTLE.....
 COST PROGRAM WRITTEN FOR THE HIRCO PROJECT.....

EXAMPLE PROBLEM.....OUTLETS

COSTS ARE BASED UPON AN ENR CONSTRUCTION COST INDEX OF 1763.

..... COST SUMMARY FOR INLETS AND OUTLETS

..... TOTAL COST INCLUDES 50% FOR CONTRACTORS PROFIT, ENGINEERING, LEGAL, AND CONTINGENCIES

NO	AVE DEPTH (FT)	PIPE DIA (IN)	PIPE DIA (IN)	TOTAL COST (K\$)
27	18.8	24.0	INLET	1.75
999	13.8	48.0	OUTLET	3.56
TOTAL FOR 2 ITEMS				5.3

TABLE VII-3
 EXAMPLE COST CALCULATION FOR INLETS/OUTLETS

PIPE, CHANNEL, OUTLET AND POND COST ANALYSIS PROGRAM.....
 PROCEDURES DEVELOPED FOR COST ANALYSIS OF DRAINAGE PROBLEMS NEAR SEATTLE.....
 COST PROGRAM WRITTEN FOR THE RISCO PROJECT.....

EXAMPLE PROBLEM.....PIPES

COSTS ARE BASED UPON AN ENR CONSTRUCTION COST INDEX OF 1763.

..... COST SUMMARY FOR PIPES

..... TOTAL COST INCLUDES 90% FOR CONTRACTORS PROFIT, ENGINEERING, LEGAL, AND CONTINGENCIES

NO	CLS	PIPE DESCRIPTION		AVG DEPTH (FT)	EXCAV VOL (CY)	PIPE COST (K\$)	EXCAV COST (K\$)	GRAV TO PIPE (K\$)	IMPORT		SHEET PILING (K\$)	DEWAT COST (K\$)	PAVE		TOTAL COST (K\$)
		DIA (IN)	LENGTH (FT)						BACK- FILL (K\$)	B-FILL (K\$)			UTIL RESTOR (K\$)		
127	3	42.0	800.	7.0	1348.	21.1	4.1	3.3	.0	.0	.0	.0	.0	3.1	62.9
128	3	36.0	1300.	6.0	1589.	20.7	4.8	3.2	.0	.0	.0	.0	.0	4.1	69.3
TOTAL FOR 2 LINES					2937.	41.7	8.9	6.5	.0	.0	.0	.0	.0	7.2	132.1

TABLE VII-4
 EXAMPLE COST CALCULATION FOR PIPES

PIPE, CHANNEL, OUTLET AND POND COST ANALYSIS PROGRAM.....
 PROCEDURES DEVELOPED FOR COST ANALYSIS OF DRAINAGE PROBLEMS NEAR SEATTLE.....
 COST PROGRAM WRITTEN FOR THE RISCO PROJECT.....

EXAMPLE PROBLEM.....POND

COSTS ARE BASED UPON AN ENR CONSTRUCTION COST INDEX OF 1763.

..... COST SUMMARY FOR HOLDING PONDS

..... SUBTOTAL COST INCLUDES 5% FOR CONTRACTORS PROFIT, ENGINEERING, LEGAL, AND CONTINGENCIES

NO	RCH	EMBANK HEIGHT (FT)	EMBANK LENGTH (FT)	VOLUME STORAGE (AF)	AREA (ACRES)	CAPACITY (CFS)	SPILL CATEGORY	LAND	EMBANK VOLUME (CY)	EMBANK COST (K\$)	OUTLET COST (K\$)	SPLWAY COST (K\$)	SUBTOT COST (K\$)	LAND COST (K\$)	TOTAL COST (K\$)
30	1	5.0	600.					2	4400.0	15.5					
30	2	8.0	1400.	60.0	9.0	200.0		2	19600.0	69.1	4.9	9.7	148.8	411.6	560.5
61	1	7.0	400.					4	4022.2	16.3					
61	2	3.0	800.					4	3200.0	11.3					
61	30	10.0	2500.	150.0	15.0	500.0		4	48888.9	172.4	4.9	14.0	329.1	1470.1	1799.3
61								4	56711.1	200.0					

..... TOTAL COST FOR 2 HOLDING PONDS 2359.7 (K\$)

TABLE VII-5
 EXAMPLE COST CALCULATION FOR HOLDING PONDS

CHAPTER VIII
PROGRAM LISTINGS

RUNOFF BLOCK

The runoff block program listing is presented on the following sheets identified as Pages 3 through 37.

* ELT CURVE,1,731128, 32680

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000301 SUBROUTINE CURVE (X,Y,NPT,NCV,NPLOT)
000302 DIMENSION X(105,10),Y(105,10),NPT(10)
000303 COMMON/LAB/ TITLE(10),XLAB(11),YLAB(6)
000304 1,HORIZ(20),VERT(7,6),IT
000305 XMAX=X(1,1)
000306 XMIN=XMAX
000307 YMIN=Y(1,1)
000308 YMAX=YMIN
000309 DO 205 L=1,NCV
000310 NPT=NPT(L)
000311 IF(NPT.EQ.0) GO TO 205
000312 DO 204 N=1,NPT
000313 IF(X(N,L).LT.XMIN) XMIN=X(N,L)
000314 IF(X(N,L).GT.XMAX) XMAX=X(N,L)
000315 IF(Y(N,L).LT.YMIN) YMIN=Y(N,L)
000316 IF(Y(N,L).GT.YMAX) YMAX=Y(N,L)
000317 204 CONTINUE
000318 205 CONTINUE
000319 RANGE=(YMAX-YMIN)/5.
000320 IF(RANGE.GT.2.) GO TO 2059
000321 IF(YMAX.GT.0.) YMIN=0.
000322 IF(YMAX.LT.0.) YMAX=0.
000323 RANGE=(YMAX-YMIN)/5.
000324 IF (RANGE.LE.0.) RETURN
000325 2059 CONTINUE
000326 A=ALOG10(RANGE)
000327 IF(A.LT.0.) GO TO 220
000328 N=A
000329 RANGE=RANGE/(10.**N)
000330 L=RANGE*1.001
000331 206 CONTINUE
000332 IF(L.EQ.2) GO TO 209
000333 IF(L.GT.4) GO TO 207
000334 L=4
000335 207 IF(L.GT.5) L=10
000336 209 CONTINUE
000337 FRANG=L*10.**N
000338 GO TO 240
000339 220 M=A-0.9999
000340 N=M
000341 RANGE=RANGE*10.**N
000342 L=RANGE*1.321
000343 226 CONTINUE
000344 IF(L.EQ.2) GO TO 229
000345 IF(L.GT.4) GO TO 227
000346 L=4
000347 227 CONTINUE
000348 IF(L.GT.5) L=10
000349 229 CONTINUE
000350 FRANG=L*10.**N
000351 240 CONTINUE
000352 K=YMIN/FRANG
000353 IF(YMIN.LT.0.) K=K-1
000354 IF(YMAX.LE.(K+5)*FRANG) GO TO 250
000355 L=L+1
000356 IF(L.LT.11) GO TO 245

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STEVE,526308,1,50

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000057 L=2
000058 N=N+1
000059 IF(A-LE,0.) N=N-2
000060 245 CONTINUE
000061 IF(A) 226,206,206
000062 250 YMIN=K*FRANG
000063 YMAX=(K+5)*FRANG
000064 XSCAL=100./(XMAX-XMIN)
000065 YSCAL=50./(YMAX-YMIN)
000066 XINT=(XMAX-XMIN)/10.
000067 YINT=(YMAX-YMIN)/5.
000068 XLAR(1)=XMIN
000069 DO 260 N=1,10
000070 XLAR(N+1)=XLAR(N)+XINT
000071 260 YLAR(6)=YMIN
000072 DO 270 N=1,5
000073 YLAR(6-N)=YLAR(7-N)+YINT
000074 270 CALL PLOT(0,0,100,NPLOT)
000075 K = 1
000076 DO 450 L=1,NCV
000077 IF(NPT(L).EQ.0) GO TO 440
000078 XO=XSCAL*(X(1,L)-XMIN)
000079 YO=YSCAL*(Y(1,L)-YMIN)
000080 NPOINT = NPT(L)
000081 DO 400 N = 2,NPOINT
000082 XT = XSCAL*(X(N,L) - XMIN)
000083 YT = YSCAL*(Y(N,L) - YMIN)
000084 CALL PINE(XO,YO,XT,YT,K,NPLOT)
000085 XO = XT
000086 YO = YT
000087 400 CONTINUE
000088 420 CONTINUE
000089 440 K = K + 1
000090 450 CONTINUE
000091 CALL PLOT(0,0,99,NPLOT)
000092 RETURN
000093 END
CURV 56
CURV 57
CURV 58
CURV 59
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CURV 61
CURV 62
CURV 63
CURV 64
CURV 65
CURV 66
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CURV 87
CURV 88
CURV 89
CURV 90
CURV 91
CURV 92

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* ELT GQUAL,1,740526, 35105

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000001 SUBROUTINE GQUAL(J,AREA,ROUT,IMSUR)
000002 C=
000003 C=.....THIS SUBROUTINE ROUTES QUALITY IN GUTTER J FOR THE FLOW VALUES
000004 C= COMPUTED IN SUBROUTINE GUTTER .. NOS QUALITIES ARE CALCULATED.....
000005 C=
000006 COMMON/ABLK/ NOS,CLIFREQ,DRYDAY,NPASS,CBVOL,
000007 1 C(200,6),COUT(200,6),PSHED(200,5),PCOFF(200,25),
000008 2 KLAND(200),DDFACT(5),DFACT(5,24),PBASIN(200),
000009 3 BASINS(200),COPACT(24),GULEN(200)
000010 DIMENSION QOUT(200),FLUX(20)
000011 DIMENSION STORPL(200,6)
000012 DATA STORPL/1200*0./
000013
000014 COMMON /TAPES/ INCNT,IOUTCT,JJIN(10),JOUT(10),NSCHAI(5)
000015 COMMON NM,NG,NIN,HISTOG,TRAIN,DELT,DELT2,NOP,NQ,NOTEP,TAREA,
000016 1 TIME,TIME2,PI,RLCOS,SUMW,SUM1,SUMOFF,SUMST,IZERO,MING
000017 COMMON WFLOW(200),WIDTH(200),WAREA(200),WSLOPE(200),WX(200),
000018 1 WSTORE(200,3),WMAX (200),WMIN(200),DECAY(200),WDEPTH(200,3),
000019 2 WCON(200,3),NAMEW(200),PCIMF(200)
000020 COMMON GFLOW(200),GWIDTH(200),GLEN(200),GSLOPE(200),GSI(200),
000021 1 GSZ(200),GNC(200),GDEPTH(200),GCON(200),NPG(200),DFULL(200),
000022 2 NGUT(200),SUMW*(200),PCTZER
000023 COMMON MATOG(200,10),NGTGG(200,10),MATOI(10),NGTOI(200)
000024 COMMON RAIN(200,10),NHYET(200),NRAIN,NROAG,NHISTO,IMISTO
000025 COMMON USUR(200),DELD(200),GJIN(200)
000026 COMMON IPHNT(200),ISAVE(200),NPHNT,NSAVE,OUTFLX(200),INTERV,
000027 1 INCNT
000028
000029 C=.....CHECK FLOW AND SET ZEROS IF BELOW MINIMUM.....
000030 C=
000031 IF( GFLOW(J) .GT. 0.005 ) GO TO 150
000032 DO 130 K=1,6
000033 COUT(J,K) = 0.0
000034 C(J,K) = 0.0
000035 130 CONTINUE
000036 RETURN
000037 150 CONTINUE
000038
000039 C=.....COMPUTE INPUTS FROM UPSTREAM GUTTERS.....
000040 C=
000041 ALFA = 2.0/DELT
000042 DO 200 M=1,6
000043 FLUX(M) = 0.
000044 IF(IMSUR,GE,M) GO TO 200
000045 PRE=IMSUR*STORPL(J,M) / (QSUR(J)-IMSUR*DELT)
000046 FLUX(M)=FLUX(M)+PREM
000047 STORPL(J,M)=STORPL(J,M)-PREM*DELT
000048 200 CONTINUE
000049 DO 240 K = 1, NIN
000050 L = NGTGG(J,K)
000051 IF( L .EQ. 0 ) GO TO 245
000052 DO 220 M=1,6
000053 FLUX(M) = FLUX(M) + C(L,M)*COUT(L)
000054 220 CONTINUE
000055 240 CONTINUE
000056

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STEVE,526308,1,50

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245 CONTINUE
C=
C=.....ADD MASS INPUT FROM ADJACENT WATERSHEDS..POFF IN LBS.....
C=
      DO 280 K = 1, NIN
      L = N*TOG(J,K)
      IF( L.EQ. 0 ) GO TO 285
      DO 260 M=1,6
      FLUX(M) = FLUX(M) + POFF(L,M)/28.317
260 CONTINUE
280 CONTINUE
285 CONTINUE
C=
C=.....COMPUT CURRENT VALUES OF GUTTER PARAMETERS FOR ROUTING.....
C=
      V = AREA*GLEN(J)
      VOUT=QIN(J)-QOUT(J)-TMSUR
      QT=QOUT(J)
      IF(TMSUR.GT.0.) QT=QT+TMSUR
      TEMP=1./((VOUT*ALFA+V*QT)
C=
C=.....COMPUTE FINAL CONCENTRATION AND UPDATE TIME PARAMETERS.....
C=
      DO 290 K=1,6
      BETA = ALFA*C(J,K) + COUT(J,K)
      C(J,K) = TEMP*( FLUX(K) + V*BETA )
      COUT(J,K) = ALFA*C(J,K) - BETA
      IF(TMSUR.GT.0.) STORPL(J,K)=STORPL(J,K)+TMSUR*C(J,K)*DELT
290 CONTINUE
      RETURN
      END

```


***-2

• ELY GRAPH, 1,743717, 57341

[illegible]

1	2
3	4
5	6
7	8

100

* ELT GUTTER,1,740725, 54490

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000001 SUBROUTINE GUTTER
000002 C
000003 C THIS SUBROUTINE COMPUTES THE INSTANTANEOUS WATER DEPTH
000004 C AND FLOW RATE FOR THE GUTTERS/PIPES
000005 C
000006 C***** SPECIFICATION STATEMENTS
000007 C
000008 COMMON /TAPES/ INCNT,IOUTCT,JIN(10),JOUT(10),NSCHMT(5)
000009 COMMON /NG,NIN,HISTOG,TRAIN,DELT,DELT2,NOM,NUG,NSTEP,TAREA,
000010 1 TIME,TIME2,MT,ROSS,SUMR,SUMI,SUMOFF,SUMST,TZLH0,NING
000011 COMMON /FLOW(200),*WIDTH(200),*AREA(200),*WSLOPE(200),*WN(200),
000012 1 *STORE(200,3),*LMAX (200),*LMIN(200),*DECAY(200),*WDEPTH(200,3),
000013 2 *CON(200,3),*NAMEK(200),*PCIMP(200)
000014 COMMON /FLOW(200),*WIDTH(200),*GLEN(200),*GWSLOPE(200),*GSI(200),
000015 1 *GSI(200),*GNC(200),*GDEPTH(200),*GCON(200),*NPQ(200),*DFULL(200),
000016 2 *NGUT(200),*SUMQM(200),*PCTZER
000017 COMMON /N*TOG(200,10),*NGTOG(200,10),*N*TOI(10),*NGTOI(200)
000018 COMMON /RAIN(200,10),*NHYTE(200),*NRAIN,*NRGAG,*NHISTO,*THISTO
000019 COMMON /DSUR(200),*DELD(200),*GIN(200)
000020 COMMON /PHNT(200),*ISAVE(200),*NPRNT,*NSAVE,*OUTFLW(200),*INTERV,
000021 1 INCNT,TITLE(40),*IPLT(200),*ICDCE(25),*NPLOT
000022 COMMON /ABLK/ NGS,CLFREQ,DRYDAY,NPASS,CBVOL,
000023 1 C(200,6),*COOT(200,6),*PSHED(200,5),*POFF(200,25),
000024 2 *KLAND(200),*DDFACT(5),*DFACT(5,24),*PSASIN(200),
000025 3 *BASINS(200),*CBFACT(24),*GLEN(200)
000026 COMMON /NEW/NAMEG(200),*NGTO(200)
000027 DATA NTSCP/0/
000028 NT31 = JOUT(1)
000029 NT32 = JOUT(2)
000030 NT1 = JOUT(3)
000031 NOUT = JOUT(4)
000032 C
000033 INLETS=NSAVE
000034 NOGG=NOG*NSAVE
000035 DO 410 N = 1, NOGG
000036 J=NGUT(N)
000037 C***** INPUTS FROM ADJACENT WATERSHED AREAS
000038 C
000039 SUMQM(J)=0.
000040 DO 220 JK=1,NIN
000041 IF (NH*TOG(J,JK).EQ.0) GO TO 240
000042 NX=NH*TOG(J,JK)
000043 220 SUMQM(J)=SUMQM(J)+M*FLOW(NX)
000044 C***** INPUTS FROM UPSTREAM GUTTERS
000045 C
000046 240 QIN(J)=SUMQM(J)
000047 DO 260 JK=1,NIN
000048 IF (NG*TOG(J,JK).EQ.0) GO TO 280
000049 NX=NG*TOG(J,JK)
000050 260 QIN(J)=QIN(J)+G*FLOW(NX)
000051 C
000052 D0=GDEPTH(J)
000053 IF (QIN(J).NE.0.) GO TO 290
000054 IF (GDEPTH(J).EQ.0.) GO TO 301
000055
000056

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STEVE,526308,1,50

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000357 290 IF(NPG(J).EQ.3) GO TO 391
000358   IFLG=0
000359   DELD(J)=0.
000360   DO 360 I=1,30
000361     TMSUR=0.
000362
000363 C***** COMPUTE CHANGE IN DEPTH (NEWTON-RAPHSON)
000364 C
000365 C***** ESTIMATED FINAL DEPTH
000366   D1=GDEPTH(J)+DELD(J)
000367   IF(NPG(J).EQ.2) GO TO 295
000368 C
000369 C*****
000370 C
000371 C***** TRAPEZOIDAL CUTTER
000372 C
000373   IF(D1.LT.0.) D1=0.
000374 C
000375 C***** VOLUME CHANGE (TRAPEZOIDAL SECTION)
000376   DELV=GLEN(J)+DELD(J)*((GS1(J)+GS2(J))*DM+0.5*DELD(J))*G*IDITH(J)
000377   DOELV=GLEN(J)*((GS1(J)+GS2(J))*D1+G*IDITH(J))
000378 C
000379 C***** CROSS-SECTIONAL AREA (TRAPEZOIDAL CROSS-SECTION)
000380   AX0=0.5*(GS1(J)+GS2(J))*DM+2*G*IDITH(J)+DM
000381   AX1=0.5*(GS1(J)+GS2(J))*D1+2*G*IDITH(J)+D1
000382   DAX1=(GS1(J)+GS2(J))*D1+G*IDITH(J)
000383 C
000384 C***** WETTED PERIMETER (TRAPEZOIDAL CROSS-SECTION)
000385   WP0=SQRT(GS1(J)**2+1.)+DM+SQRT(GS2(J)**2+1.)+DM*G*IDITH(J)
000386   WP1=SQRT(GS1(J)**2+1.)+D1+SQRT(GS2(J)**2+1.)+D1*G*IDITH(J)
000387   DWP1=SQRT(GS1(J)**2+1.)+SQRT(GS2(J)**2+1.)
000388   GO TO 315
000389 C
000390 C***** CIRCULAR PIPE
000391 C
000392 C
000393 295 IF(I.GT.1) GO TO 307
000394   D1=1.5707963
000395   DELD(J)=D1-GDEPTH(J)
000396   307 IF(D1.GT.0.) GO TO 308
000397   D1=0.
000398   DELD(J)=GDEPTH(J)
000399   308 IF(D1.LE.DFULL(J)) GO TO 310
000400   D1=DFULL(J)
000401   DELD(J)=D1-GDEPTH(J)
000402 C
000403 C***** VOLUME CHANGE (PIPE)
000404   310 DELV=GLEN(J)*(G*IDITH(J)**2/4.)*(DELD(J)-0.5*SIN(2.*D1)
000405     1+0.5*SIN(2.*DM))
000406   DOELV=GLEN(J)*(G*IDITH(J)**2/4.)*(1.-COS(2.*D1))
000407 C
000408 C***** CROSS-SECTIONAL AREA (PIPE)
000409   AX0=(G*IDITH(J)**2/4.)*(DM+0.5*SIN(2.*DM))
000410   AX1=(G*IDITH(J)**2/4.)*(D1+0.5*SIN(2.*D1))
000411   DAX1=(G*IDITH(J)**2/4.)*(1.-COS(2.*D1))
000412 C
000413 C***** WETTED PERIMETER (PIPE)
000414   WP0=G*IDITH(J)+DM
000415   WP1=G*IDITH(J)+D1
000416

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STEVE,526308,1,50

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000117      DMP1=GWIDTH(J)
000118      C
000119      C
000120      C
000121      C***** HYDRAULIC RADIUS (ALL CROSS-SECTIONS)
000122      315 IF(AXD.LT.0.) AXD=0.
000123      IF(AX1.LT.0.) AX1=0.
000124      IF(WP0.LE.0.) WP0=0.001
000125      IF(WP1.LE.0.) WP1=0.001
000126      RAD1=AX0/MP0
000127      RAD1=AX1/MP1
000128      C
000129      C***** FLOW
000130      FLOW=GCN(J)*(AX0**1.6666667)/(WP0**0.66666667)
000131      FLOW1=GCN(J)*(AX1**1.6666667)/(WP1**0.66666667)
000132      OUTFLW(J) = FLOW1
000133      FLOW=0.5*(FLOW0+FLOW1)
000134      DFLOW1=M.5*GCN(J)*((1.6666667*(RAD1**0.6666667)*DAX1
000135      1 -0.6666667*(RAD1**1.666667)*DMP1)
000136      C
000137      C***** NEWTON-RAPHSON CORRECTION (ALL CROSS-SECTIONS)
000138      FDELV=DEL*(FLOW-GIN(J))-GSUR(J)
000139      DF=DELV/DEL*DFLOW1
000140      C
000141      IF(DF.GT.0.) GO TO 320
000142      C***** ZERO SLOPE
000143      DEL=0.01
000144      GO TO 340
000145      C***** NON-ZERO SLOPE
000146      320 DEL=DEL(J)-F/DF
000147      C***** CONVERGENCE CHECK (INDIVIDUAL GUTTER)
000148      340 IF(1.FQ.1) GO TO 360
000149      IF(GDEP(H(J))*DEL.LT.0FULL(J)) GO TO 355
000150      IF(1FLG.EQ.1) GO TO 390
000151      DEL=DFULL(J)-GDEP(H(J))
000152      1FLG=1
000153      GO TO 360
000154      355 1FLG=0
000155      IF(ABS(F).LT.0.1) GO TO 380
000156      360 DEL(J)=DEL
000157      1000 WRITE(6,1000) TIME,J,GDEP(H(J)),DELD(J)
000158      1000 FORMAT(1 CHECK RESULTS. NOT CONVERGED IN *GUTTER*1,
000159      1 F8.0,16.2E12.5)
000160      DEL=0
000161      D=GDEP(H(J))
000162      FLOW=GCN(J)*J.14/(4**1.667)*D**2.667
000163      C
000164      C***** NEW DEPTH AT END OF TIME INTERVAL
000165      380 DELD(J)=DEL
000166      GDEP(H(J))=GDEP(H(J))+DELD(J)
000167      GSUR(J)=0.
000168      C
000169      C***** AVERAGE FLOW DURING TIME INTERVAL
000170      C
000171      IF(FLOW.LT.1.E-10) FLOW=0.0
000172      GFLOW(J)=FLOW
000173      GO TO 430
000174      C
000175      C***** SURCHARGE
000176      C

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STEVE,5263W8,1,50

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000177 C 390 GDEPT=(J)*DFULL(J)
000178 GFLC(J)=FLO*1
000179 T=SUR*2IN(JJ)-FLO*
000180 QSUR(J)=QSUR(J)+T*SUR*DELT
000181 IF(QSUR(J).GT.0.) GO TO 400
000182 GFLC(J)=GFLC(J)+QSUR(J)/2.
000183 QSUR(J)=0.
000184 OUTFL(J)=GFLC(J)+QSUR(J)/2.
000185 GFLC(J)=QIN(J)
000186 391 IF(NQS.GT.0) CALL GQUAL(J,AXI,OUTFL*,TMSUR)
000187 400 IF(NQS.GT.0) CALL GQUAL(J,AXI,OUTFL*,TMSUR)
000188 410 CONTINUE
000189 C
000190 C
000191 C
000192 NOT=NQS
000193 IF(NGT.LT.1) NGT=1
000194 IF(NPRNT.LT.1) GO TO 510
000195 INTCNT=INTCNT+1
000196 IF(INTCNT.LT.INTERV) GO TO 510
000197 INTCNT=0
000198 DO 500 N=1,NPRNT
000199 J=IPRNT(N)
000200 500 OUTFL(N)=QIN(J)
000201 TIME=TIME/3600.
000202 TIME=TIME/60.-FLOAT(INTIME)*60.
000203 WRITE(NT1) NTIME,TIME,OUTFL(N),N=1,NPRNT)
000204 IF(NQS.LT.1) GO TO 504
000205 DO 503 J=1,NPRNT
000206 N=IPRNT(J)
000207 DO 502 K=1,NQS
000208 POFF(J,K)=C(N,6)*CBFACT(K)
000209 DO 501 L=1,5
000210 POFF(J,K)=C(N,L)*OFAC(L,K)*POFF(J,K)
000211 501 CONTINUE
000212 502 CONTINUE
000213 503 CONTINUE
000214 WRITE(NT1) NTIME,TIME,((POFF(J,K),K=1,NQS),J=1,NPRNT)
000215 504 CONTINUE
000216 THX = TIME/3600.0
000217 DO 505 N=1,NQC
000218 J=NGUT(N)
000219 IF(QSUR(J).LE.0.0) GO TO 505
000220 NTSCP = NTSCP + 1
000221 IF(MOD(NTSCP,36) .EQ. 1) WRITE(6,5003)
000222 5003 FORMAT(1H / 5X, 'SUMMARY OF SURCHARGE HISTORY' // 5X,
000223 1 'TOTAL GUTTER CUM VOL/1 HOUR MIN (FT3)' )
000224 2FLOW SURCHAR' / 3X, 1(HOURS) NUMBER (CFS)
000225 WRITE(6,9400) NTIME,TIME,NAMEG(J),GFLC(J),QSUR(J)
000226 9400 FORMAT(15,F5.0,110,F10.1,F10.0)
000227 505 CONTINUE
000228 WRITE(6,5004)
000229 5004 FORMAT( )
000230 C
000231 C
000232 C
000233 510 IF(NOUT.LT.1) GO TO 610
000234 IF(NPLOT.EQ.0) GO TO 610
000235 DO 600 N=1,NPLOT
000236 J=IPLOT(N)
000237 WRITE INLETS TO BE SAVED
000238 GUT173
000239 GUT174
000240 GUT175
000241 *NE*

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STEVE,526308,1,50

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010237 DO 561 K = 1, NQT
010238   POFF(N,K)=C(J,6)*CBFACT(K)
010239   DO 568 L=1,5
010240     568 POFF(N,K)=POFF(N,K)+C(J,L)*QFACT(L,K)
010241     561 POFF(N,K)=POFF(N,K)+QIN(J)*6.24286E-5
010242     648 OUTFLW(N) = QIN(J)
010243     WRITE(OUT) TIME,(OUTFLW(N),N=1,NPLOT),((POFF(N,K),K=1,NQT),
010244       1=N=1,NPLOT)
010245   618 CONTINUE
010246 C=
010247 C=.....WRITE PERMANENT QUANTITY AND QUALITY TAPES.....
010248 C=
010249   IF( INLETS .LT. 1 ) GO TO 670
010250   IF( NTS1 .LT. 1 ) GO TO 630
010251 C=
010252 C=.....QUANTITY TAPE.....
010253 C=
010254   DO 620 N = 1, INLETS
010255     J = NGTOI(N)
010256     OUTFLW(N) = QIN(J)
010257   620 CONTINUE
010258   WRITE(NTS1) TIME,(OUTFLW(N),N=1,INLETS)
010259 C=
010260 C=.....QUALITY TAPE.....
010261 C=
010262   630 IF(NTS2.LT.1) GO TO 670
010263   IF(NUS.LT.1) GO TO 668
010264   DO 640 N = 1, INLETS
010265     J = NGTOI(N)
010266     DO 635 K=1,6
010267       POFF(N,K)=C(J,K)*QIN(J)*6.24286E-5
010268   635 CONTINUE
010269   640 CONTINUE
010270   668 CONTINUE
010271   1 WRITE(NTS2) TIME,(OUTFLW(N),N=1,INLETS),
010272     (PCFF(N,K),K=1,6),N=1,INLETS)
010273   670 CONTINUE
010274 C
010275   RETURN
010276   END

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GUTTI82

IPK
IPKIPK
IPKGUTTI83
GUTTI84
GUTTI85

• ELT H RVE,L,740326, 55788

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000801 SUBROUTINE HCURVE(NTYPE,INLET)
000802 COMMON NM,NG,NIN,HISTOG,THRAIN,DELT,DEL2,NOM,NOG,NSTEP,IAREA,
000803 1 TIME,TIME2,H1,ALOSS,SUMH,SUMI,SUMOFF,SUMST,TZERO,ALNG
000804 COMMON WFO,LO,LOP,WMIDTH(200),WAREA(200),WSLOPE(200),WN(200),
000805 1 WSTORE(200,3),WLMAX (200),WLMIN(200),WDECAT(200),WDEFTM(200,3),
000806 2 WCON(200,3),WNAME(200),WPCIMP(200)
000807 COMMON GFLO,GFLOP,GMIDTH(200),GLEN(200),GSLOPE(200),GSI(200),
000808 1 GS2(200),GN(200),GDEPTH(200),GCON(200),NPG(200),DFULL(200),
000809 2 NGUT(200),SUMOM(200),PCTZER
000810 COMMON NATOG(200,10),NGTGG(200,10),NATOI(10),NGTOI(200)
000811 COMMON RAIN(200,10),NHYET(200),NRAIN,NRGAG,NHISTO,TWISTO
000812 COMMON OSUR(200),DELD(200),GIN(200)
000813 COMMON IPHNT(200),ISAVE(200),NPRAT,NSAVE,OUTFLW(200),INTERV,
000814 1 INTENT,DUMMY(40),IPLOT(200),ICODE(25),NPLQ
000815 COMMON HGRAPH(200),HTIME(200)
000816 COMMON X(101,5),Y(101,5),NPI(5)
000817 COMMON LAB/ TITLE(18),XLAB(11),YLAB(6)
000818 1 HORIZ(20),VERT(7,6),IT
000819 DIMENSION VER(7,2),ITITL(7,2)
000820 DIMENSION TITEL(18),ORIZ(20)
000821 DATA TITL / 16*4H ,4H BASI,4H NQ /
000822 DATA ORIZ / 8*4H ,4H TIME,4H IN ,4H HOUR,4H ,8*4H /
000823 DATA VER / 4HRAIN,4H FALL,4H HYE,4H TOGR,4HAPH ,4H ,4H ,
000824 1,4H RUN,4H OFF ,4H 1,4H N ,4H CF,4H ,4H /
000825 DO 750 I=1,18
000826 750 TITEL(I)=TITEL(I)
000827 DO 760 I=1,20
000828 760 HORIZ(I)=HORIZ(I)
000829 C HAINFALL HYETOGRAPH OR INLET HYDROGRAPH
000830 DO 5 I=1,7
000831 J = I+2
000832 IT=NTYPE
000833 VERT(I,IT)=VER(I,NTYPE)
000834 TITEL(J) = TITL(I,NTYPE)
000835 5 CONTINUE
000836 IF(NTYPE.GT.1) GO TO 380
000837 NGAGP=5
000838 TMAX=FLOAT(NSTEP)*DELT+TZERO
000839 I=0
000840 DO 350 J=1,NRGAG,NGAGP
000841 DO 300 K=1,NCAGP
000842 I=I+1
000843 IF(I.GT.NRGAG) GO TO 320
000844 TIME=TZERO
000845 DO 250 L=1,NHISTO
000846 N=N+1
000847 X(N,K)=TIME/3600.
000848 Y(N,K)=RAIN(L,I)*43200.
000849 TIME=TIME+ HISTOG
000850 IF(TIME.GT.1MAX) GO TO 300
000851 IF(NHISTO.GT.50) GO TO 250
000852 N=N+1
000853 X(N,K)=TIME/3600.
000854
000855
000856

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000057 Y(N,K)=RAIN(I,I)*43200.
000058 N=N+1
000059 X(N,K)=TMAX/3600.
000060 Y(N,K)=0.
000061 NPT(K)=N.
000062 K=NGAGP+1
000063 K=K-1
000064 CALL CURVE(X,Y,NPT,K,INLET)
000065 JT=J-K-1
000066 WRITE(6,9000) (K,K=J,JT)
000067 FORMAT(30X,'RAINGAGE LEGEND',I8,4H = *,I8,4H = *,I8,4H = *,I8,
000068 14H = X,I8,4H = .)
000069 350 CONTINUE
000070 RETURN
000071 380 X(1,1)=HTIME(I)
000072 Y(1,1)=HGRAPH(I)
000073 CHOOSE THE SCALE DOWN FACTOR
000074 M=(NSTEP+99)/100
000075 I = 1
000076 DO 10 J = M,NSTEP,M
000077 I = I + 1
000078 X(I,1)=HTIME(I)
000079 Y(I,1)=HGRAPH(I)
000080 10 CONTINUE
000081 48 NPT(I)=I
000082 CALL CURVE(X,Y,NPT,I,INLET)
000083 RETURN
000084 END
000085
HCUR 32
HCUR 33
HCUR 34
HCUR 35
HCUR 36
HCUR 39
HCUR 46
HCUR 47
HCUR 48
HCUR 49

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STEVE,526308,1,50

• ELT HYDRO,1,74W326, 55793

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000001 SUBROUTINE HYDRO
000002 C
000003 C ***** SPECIFICATION STATEMENTS
000004 C
000005 COMMON NM,NIN,HISTOG,IRAIN,DELT,DEL12,NOM,ACG,NSTEP,IAREA,
000006 1 TIME,TIME2,M1,PLOSS,SUMR,SUMI,SUMOFF,SUMST,IZERON,NING
000007 COMMON WFLOW(200),WIDTH(200),WAREA(200),WSLOPE(200),W(200),
000008 1 WSTORE(200,3),WMAX(200),WMIN(200),WDECA(200),WDEPTH(200,3),
000009 2 WCON(200,3),WAVE(200),PCIMP(200)
000010 COMMON GFLW(200),GIDTH(200),GLEN(200),GSLOPE(200),GSI(200),
000011 1 GS2(200),GN(200),GDEPTH(200),GCON(200),NPG(200),DFULL(200),
000012 2 NGUT(200),SUMOM(200),PCIZLR
000013 COMMON NWTG(200,10),NGTGG(200,10),NWTG(10),NGTGT(200)
000014 COMMON RAIN(200,10),NHVET(200),RAIN,NRGAG,NHISTO,INISTO
000015 COMMON QSUR(200),DELD(200),QIN(200)
000016 COMMON IPRNT(200),ISAVE(200),NPRNT,NSAVE,CUTFLW(200),INTERV,
000017 1 INTCNT,ITILE(40),IPLGT(200),ICODE(25),NPLCT
000018 COMMON MGRAPH(200),NTIME(200)
000019 COMMON/TAPES/ INTC,IOUCNT,JJIN(10),JOUT(10),NSCRAT(5)
000020 COMMON/ABLK/ NGS,CLFREG,DRYDAY,NPASS,CBVOL,
000021 1 C(200,6),CDDT(200,6),PSED(200,5),POFF(200,25),
000022 2 KLAND(200),ODEACT(5),QFACT(5,24),PBASIN(200),
000023 3 BASINS(200),CRFACT(200),GLEN(200)
000024 COMMON/INFIL/ RAININ(200),DEPIN(200)
000025 C ***** INITIALIZATION
000026 C
000027 NW=200
000028 NG=200
000029 NING=200
000030 NRAWL=200
000031 NIN=10
000032 INTCNT=0
000033 DO 220 I=1,NW
000034 RAININ(I)=0.0
000035 WFLOW(I)=0.0
000036 WIDTH(I)=0.0
000037 WDEPTH(I,1)=0.0
000038 WDEPTH(I,3)=0.0
000039 WDEPTH(I,2)=0.0
000040 DO 240 I=1,NG
000041 NPG(I)=0
000042 NGUT(I)=0
000043 QSUR(I)=0.0
000044 DELD(I)=0.0
000045 QIN(I)=0.0
000046 GFLW(I)=0.0
000047 GDEPTH(I)=0.0
000048 GLEN(I)=0.0
000049 DO 250 J=1,NING
000050 NGTGT(J)=0
000051 DO 260 J=1,NIN
000052 NWTG(J)=0
000053 DO 260 I=1,NG
000054 NWTG(I,J)=0
000055 260 NGTGG(I,J)=0
000056
HYDR 2
HYDR 3
HYDR 4
HYDR 5
HYDR 19
HYDR 20
HYDR 21
HYDR 25
HYDR 26
HYDR 27
HYDR 28
HYDR 29
HYDR 30
HYDR 31
HYDR 32
HYDR 33
HYDR 34
HYDR 35
HYDR 36
HYDR 37
HYDR 38
HYDR 39
HYDR 40
HYDR 41
HYDR 42
HYDR 43
HYDR 44
HYDR 45
HYDR 46
HYDR 47
HYDR 48

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000057 DO 280 I=1,NRANVL
000058 HGRAPH(I)=0.
000059 HTIME(I)=0.
000060 DO 280 J=1,10
000061 280 RAIN(I,J)=0.
000062 SUMR = 0.0
000063 SUMI = 0.0
000064 SUMOFF = 0.0
000065 SUMST = 0.0
000066
000067 C----- CALL INPUT SUBROUTINE
000068 C
000069 CALL RHYDRO(BASIN)
000070 TIME=ZERO
000071 C
000072 C----- SET UP ORDERING ARRAY
000073 DO 2200 I=1,NING
000074 IF(NGTOI(I).EQ.0) GO TO 2220
000075 NSPOT=NG+1-I
000076 NGUT(NSPOT)=NGTOI(I)
000077 C----- BUILD TREE STRUCTURE
000078 2220 DO 2260 I=1,NG
000079 KSPOT=NG+1-I
000080 ISUR=NGUT(KSPOT)
000081 IF(ISUB.LE.0) GO TO 2260
000082 DO 2240 J=1,NIN
000083 IF(NGTOC(ISUB,J).EQ.0) GO TO 2260
000084 NSPOT=NSPOT+1
000085 2240 NGUT(NSPOT)=NGTOC(ISUB,J)
000086 2260 CONTINUE
000087 C----- SHIFT TO START OF ARRAY
000088 NSPOT=0
000089 DO 2280 I=1,NG
000090 IF(NGUT(I).EQ.0) GO TO 2280
000091 NSPOT=NSPOT+1
000092 NGUT(NSPOT)=NGUT(I)
000093 2280 CONTINUE
000094 C-
000095 C----- INITIALIZE WATERSHED POLLUTION LOADS.....
000096 C-
000097 IF( NGS .GT. 0 ) CALL GSNEDI
000098 C
000099 C----- CALCULATE INLET HYDROGRAPHS
000100 C
000101 M=(NSTEP+99)/100
000102 I=1
000103 HTIME(1)=TZERO/3600.
000104 DO 440 II=1,NSTEP,M
000105 I=I+1
000106 DO 430 IJ=1,M
000107 TIME=TIME+DELT
000108 TIME2=TIME-DELT2
000109 HTIME(IJ)=TIME/3600.
000110 C
000111 C----- WATERSHED ELEMENTS (OVERLAND FLOW)
000112 C
000113 CALL WSHED
000114 C-
000115 C----- WATERSHED QUALITY CONTRIBUTIONS.....
000116 C-
HYDR 49
HYDR 50
HYDR 51
HYDR 55
HYDR 56
HYDR 57
HYDR 58
HYDR 59
HYDR 60
HYDR 61
HYDR 63
HYDR 64
HYDR 65
HYDR 66
HYDR 67
HYDR 68
HYDR 69
HYDR 70
HYDR 71
HYDR 72
HYDR 73
HYDR 74
HYDR 75
HYDR 76
HYDR 77
HYDR 78
HYDR 79
HYDR 80
HYDR 81
HYDR 82
HYDR 83
HYDR 84
HYDR 85
HYDR 86
HYDR 88
HYDR 89
HYDR 91
HYDR 92
HYDR 93
HYDR 94
HYDR 95
HYDR 97
HYDR 98
HYDR 99
HYDR100

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ST=0.526308,1.50

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000117      IF( NDS .GT. 0 ) CALL QSHED2
000118      C
000119      C***** GUTTER ELEMENTS
000120      C
000121      IF( NDS .GT. 0 ) CALL GUTTER
000122      340 CONTINUE
000123      C
000124      C***** HYDROGRAPH CONSTRUCTION
000125      C
000126      C***** SUM INLET FLOWS OVER THE BASIN
000127      HGRAPH(I)=0.0
000128      380 IF( NDS.EQ.0 ) GO TO 420
000129      DO 400 JK=1,NING
000130      IF( NGTOI(JK).EQ.0 ) GO TO 420
000131      NX=NGTOI(JK)
000132      HGRAPH(I)=HGRAPH(I)+GFLOW(NX)
000133      400 CONTINUE
000134      C***** SUM FOR CONTINUITY CHECK
000135      SUMOFF=SUMOFF+HGRAPH(I)*DELT
000136      C
000137      430 CONTINUE
000138      440 CONTINUE
000139      C
000140      C***** CONTINUITY CHECK
000141      DO 460 J=1,NOW
000142      SUM=SUMST+DEPTH(J,1)*AREA(J)*PCIMP(J)/10000.+(100.-PCTZER)
000143      1=DEPTH(J,2)*(100.-PCIMP(J))/100.
000144      450 CONTINUE
000145      ERROR=(SUMR-SUMI-SUMOFF-SUMST)*100./SUMR
000146      WRITE(6,9000) SUMR,SUMI,SUMOFF,SUMST,ERROR
000147      9000 FORMAT(11TOTAL RAINFALL (CU FT)
000148      1 TOTAL INFILTRATION (CU FT)
000149      2 TOTAL GUTTER FLOW AT INLET (CU FT)
000150      3 TOTAL SURFACE STORAGE AT END OF STORM (CU FT)
000151      4 ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL, 1,F10.5)
000152      C
000153      C*****CLOSE OUTPUT FILES*****
000154      C
000155      NT1 = JOUT(3)
000156      IF( NT1 .LT. 1 ) GO TO 470
000157      IEOF = -1
000158      WRITE(NT1) IEOF,IEOF,(OUTFL*(N),N=1,NPRNT)
000159      470 CONTINUE
000160      C
000161      C***** OUTPUT
000162      C
000163      CALL HCURVE(1,BASIN)
000164      CALL HCURVE(2,BASIN)
000165      CALL GRAPH(ICODE)
000166      RETURN
000167      END

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• ELT PINE,1,731128, 32683

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000001 SUBROUTINE PINE(X1,Y1,X2,Y2,NSYM,NCT)
000002   AX=AX1
000003   AY=AY1
000004   IYB=IY2
000005   N=1
000006   IF (ABS(AXB-AXA).LT.ABS(AYB-AYA)) GO TO 290
000007   IF (ABS(AXB-AXA).LT.ABS(AYB-AYA)) GO TO 290
000008   N=1
000009   C
000010   C SET PARAMETERS FOR X DIRECTION
000011   C
000012   IF (AXB-AXA) 241,400,245
000013   241 CONTINUE
000014   AX=AX1
000015   AY=AY1
000016   IYB=IY2
000017   245 CONTINUE
000018   IYB=IYB+.5
000019   IYB=IYB+.5
000020   IYB=IYB+.5
000021   IYB=IYB+.5
000022   250 CONTINUE
000023   IF (IXA-LT.0.OR.IXA.GT.100) GO TO 260
000024   IF (IYA-LT.0.OR.IYA.GT.50) GO TO 260
000025   CALL PLOT(IXA,IYA,NSYM,NCT)
000026   260 CONTINUE
000027   IXA=IXA+1
000028   IYA=(N*(AYB-AYA))/(AXB-AXA)
000029   IYA=IYA+.5
000030   N=N+1
000031   IF (IXA.LE.IXB) GO TO 250
000032   GO TO 400
000033   C
000034   C SET PARAMETERS FOR Y DIRECTION
000035   C
000036   290 CONTINUE
000037   IF (AYB-CT.AYA) GO TO 295
000038   AYB=AY1
000039   AYB=AY2
000040   AXB=AX1
000041   AXB=AX2
000042   295 CONTINUE
000043   IYB=IYB+.5
000044   IYB=IYB+.5
000045   IYB=IYB+.5
000046   IYB=IYB+.5
000047   300 CONTINUE
000048   IF (IXA-LT.0.OR.IXA.GT.100) GO TO 310
000049   IF (IYA-LT.0.OR.IYA.GT.50) GO TO 310
000050   CALL PLOT(IXA,IYA,NSYM,NCT)
000051   310 CONTINUE
000052   IYA=IYA+1
000053   IYA=(N*(AXB-AXA))/(AYB-AYA)
000054   IYA=IYA+.5
000055   N=N+1
000056   IF (IYA.LE.IYB) 300,320,400

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STEVE, 526388, 1.50

320 IKA = IX8
GO TO 300
400 RETURN
END

000057
000058
000059
000060

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PINE 64
PINE 57
PINE 55
PINE 59

* EL7 PLOT,1,740717, 57346

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010001 SURROUTINE PLOT(IX,IY,K,NCT)
010002 DIMENSION A(51,101),SYM(9)
010003 COMMON /LAB/ TITLE(18),XLAB(11),YLAB(6)
010004 I,HORIZ(20),VERT(7,6),IT
010005 DATA SYM / 4H****,4H****, 4H***, 4H****, 4H****, 4H2222,
010006 1 4H , 4HIII, 4H---- /
010007 IF(K-99) 200,220,230
010008 200 A(51-IY,IX+1)=SYM(K)
010009 RETURN
010010 220 CONTINUE
010011 I=0
010012 WRITE(6,103) TITLE,NCT
010013 DO 225 II=1,6
010014 I=I+1
010015 WRITE(6,101) YLAB(II),(A(I,J),J=1,101)
010016 IF(II.EQ.6) GO TO 228
010017 DO 224 JJ=1,9
010018 I=I+1
010019 IF(II.EQ.28) GO TO 221
010020 WRITE (6,108) VERT(5,IT),VERT(6,IT),VERT(7,IT),(A(I,J),J=1,101)
010021 GO TO 224
010022 221 IF(II.EQ.24) GO TO 222
010023 WRITE (6,106) VERT(1,IT),VERT(2,IT),(A(I,J),J=1,101)
010024 GO TO 224
010025 222 IF(II.EQ.26) GO TO 223
010026 WRITE (6,106) VERT(3,IT),VERT(4,IT),(A(I,J),J=1,101)
010027 GO TO 224
010028 223 WRITE(6,100) (A(I,J),J=1,101)
010029 224 CONTINUE
010030 225 CONTINUE
010031 228 CONTINUE
010032 WRITE(6,102) XLAB
010033 WRITE(6,105) HORIZ
010034 100 FORMAT(18X,101A1)
010035 101 FORMAT( 1 , 1PE16.2,1X, 101A1 )
010036 102 FORMAT( 1 , F19.1,1PE10.1)
010037 103 FORMAT(1H,20X,18A4,16/)
010038 105 FORMAT(30X,20A4)
010039 106 FORMAT(3X,2A4,7X,101A1)
010040 107 FORMAT( 1 , 1PE16.2,1X,101A1)
010041 108 FORMAT (3X,3A4,3X,101A1)
010042 230 DO 250 I=1,50
010043 DO 240 J=1,101
010044 A(I,J)=SYM(7)
010045 A(I,1)=SYM(8)
010046 250 CONTINUE
010047 DO 260 J=1,101
010048 A(51,J)=SYM(9)
010049 DO 270 I=1,101,10
010050 A(51,I)=SYM(8)
010051 DO 290 I=11,41,10
010052 A(I,1)=SYM(9)
010053 290 CONTINUE
010054 RETURN
010055 END

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* ELT QSHED,1.740318, 57126

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000001 SUBROUTINE QSHED1
000002 C=
000003 C=.....THIS ROUTINE COMPUTES THE MASS RUNOFF RATE (MG) FROM EACH
000004 C=.....SYSTEM WATERSHED.....
000005 C=
000006 COMMON /TAPES/ INCNT,IOUCT, JIN(10),JOUT(10),NSCHAT(5)
000007 COMMON NM,NG,NIN,HISTOG,THAIN,DELT,DELT2,NOM,NOG,NGSTEP,IAREA,
000008 1 TIME,TIME2,RI,ROSS,SUMP,SUM-1,SUMOFF,SUMSI,IZER,NING
000009 COMMON MFLON(200),MIDITH(200),MAHEA(200),MSLOPE(200),MNN(200),
000010 1 WSTORE(200,3),MLMAX (200),MLMIN(200),DECAY(200),WDEPTH(200,3),
000011 2 WCON(200,3),NAMEW(200),PCIMP(200)
000012 COMMON GFLON(200),GMIDITH(200),GLEN(200),GSLOPE(200),GSI(200),
000013 1 GS2(200),GN(200),GDEPTH(200),GCON(200),MPG(200),DFULL(200),
000014 2 NGUT(200),SUMQM(200),PCTZER
000015 COMMON NMTOG(200,10),NGIOG(200,10),NATOI(10),NGIOI(200)
000016 COMMON RAIN(200,10),ANYEI(200),NHAIN,NRGAG,NHISTO,THISTO
000017 COMMON QSOR(200),DELD(200),GIN(200)
000018 COMMON IPHNT(200),ISAVE(200),NPRNT,NSAVE,OUTFLW(200),INTERV,
000019 1 INTCNT
000020 COMMON/ABLK/ NGS,CLFREQ,DRYDAY,NPASS,CBVOL,
000021 1 C(200,6),CDDT(200,6),PSHED(200,5),POFF(200,25),
000022 2 KLAND(200),DOFACT(5),QFACT(5,24),PBASIN(200),
000023 3 BASINS(200),CBFACT(24),GLEN(200)
000024
000025 C=.....SETUP INITIAL POLLUTION LOADINGS.....
000026 C=
000027 C=.....START WITH WATERSHEDS.....
000028 C=
000029 DRY = DRYDAY
000030 IF( CLFREQ .GT. DRYDAY .OR. CLFREQ .LT. 1.0 ) GO TO 130
000031 NCLEAN = DRYDAY/CLFREQ
000032
000033 C=.....DETERMINE CLEANING EFFICIENCY.....
000034 C=
000035 REFF = 0.98
000036 IF( NPASS .GT. 2 ) GO TO 120
000037 IF( NPASS .EQ. 2 ) GO TO 115
000038 REFF = 0.60
000039 IF( CLFREQ .LT. 15.0 ) REFF = 0.70
000040 IF( CLFREQ .LT. 0.0 ) REFF = 0.75
000041 GO TO 120
000042 115 REFF = 0.88
000043 IF( CLFREQ .LT. 15.0 ) REFF = 0.92
000044 IF( CLFREQ .LT. 0.0 ) REFF = 0.95
000045
000046 C=.....ACCOUNT FOR STREET SLEEPING.....
000047 C=
000048 120 ICS = 1.0
000049 DO 125 J = 1, NCLEAN
000050 ICS = ICS + ( 1.0 - REFF ) ** J
000051 125 CONTINUE
000052 DRY = CLFREQ * ICS
000053
000054 C=.....COMPUTE WATERSHED LOADINGS.....
000055 C=
000056 130 DO 150 N = 1, NOM

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GUTT 21

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000357 J = KLAND(N)
000358 IF( J.LE.0 ) J = 5
000359 DO = DFACT(J)*DRY*CGLEN(N)*453.6
000360 DO 135 K=1,5
000361 135 PSHED(N,K)=0.
000362 PSHED(N,J)=DO
000363 140 CONTINUE
000364 C=
000365 C=.....COMPUTE CATCHBASIN LOADINGS.....
000366 C=
000367 PBASIN(J)=CBVOL*BASINS(N)*28.3
000368 145 CONTINUE
000369 150 CONTINUE
000370 C=
000371 RETURN
000372 C=
000373 C=.....ENTRY QSHED2 PERFORMS THE TIME DEPENDENT ROUTING OF MATERIAL.....
000374 C= FROM STORAGE ON THE WATERSHEDS AND IN THE CATCHBASINS.....
000375 C=
000376 ENTRY QSHED2
000377 C=
000378 C=.....ENTER LOOP ON WATERSHEDS.....
000379 C=
000380 DO 300 N = 1, NOW
000381 C=
000382 C=.....COMPUTE RUNOFF AND DECAY COEFFICIENTS.....
000383 C=
000384 H = 12.0*FLOW(N)/WAREA(N)
000385 DFACT = EXP( -4.6*R*DELT )
000386 RATE = 4.6*R
000387 C=
000388 C=.....DECAY MATERIAL FROM EACH WATERSHED AND COMPUTE CURRENT RATE
000389 C= OF MASS RUNOFF (MG/SEC).....
000390 C=
000391 DO 210 J=1,5
000392 PSHED(N,J) = PSHED(N,J)*DFACT
000393 POFF(N,J) = PSHED(N,J)*RATE
000394 210 CONTINUE
000395 C=
000396 C=.....COMPUTE CATCHBASIN CONTRIBUTION.....
000397 C=
000398 IF(BASINS(N).LT..05) GO TO 300
000399 RATE = FLOW(N)/(1.6*CBVOL*BASINS(N))
000400 DFACT = EXP( - RATE )
000401 PBASIN(N)=PRASIN(N)*DFACT
000402 POFF(N,6)=POFF(N,6)+RATE*PRASIN(N)
000403 220 CONTINUE
000404 300 CONTINUE
000405 RETURN
000406 END

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* ELT RECAP,1,740423, 59585

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000001 SUBROUTINE RECAP
000002 COMMON/TAPES/ INCNT,IOUTCT,JIN(10),JOUT(10),NSCRAT(5)
000003 COMMON FLOW(200),QUAL(200,24),IPRNT(200),TITLE(40)
000004 1 ,NHR(100),TMIN(100),OUT(100,12),FLOWOT(100)
000005 C=
000006 C=-----READ TAPE HEADERS-----
000007 C=
000008 IF( JOUT(3) .LT. 1 ) RETURN
000009 NT1 = JOUT(3)
000010 REMIND NT1
000011 READ(NT1) TITLE
000012 READ(NT1) NSTEP,NPTS,NQS,DELT,TZERO,TAREA
000013 READ(NT1)(IPRNT(K),K=1,NPTS)
000014 IF( NQS .LT. 1 ) GO TO 300
000015 NREAD = NSTEP
000016 DO 200 J = 1, NPTS
000017 REMIND NT1
000018 READ(NT1) TITLE
000019 READ(NT1) NTX
000020 READ(NT1) NTX
000021 WRITE(6,6000) TITLE, IPRNT(J)
000022 6000 FORMAT( 1H1 / 10X, 20A4 / 10X, 'SUMMARY OF QUANTITY AN
10 QUALITY RESULTS AT LOCATION',15// 10X, 'FLOW IN CFS AND QUALITY I
2N (MG/L) EXCEPT COLIFORMS IN (MPN/100ML)',//
3AX,TIME FLOW SET-S SUS-S TDS BOD COO
4CHLOR S04 GREASE TOT-COL FEC-COL NH3 ORG-NIT')
000026 NRD=NREAD
000027 DO 198 K = 1, NREAD
000028 READ(NT1) NTIMEH,TIMEH,(FLOW(N),N=1,NPTS)
000029 IF(NTIMEH.NE.-1) GO TO 140
000030 NRD=NK-1
000031 GO TO 192
000032 140 IF( NQS .LT. 1 ) GO TO 160
000033 READ(NT1) NTIMEH,TIMEH,((QUAL(M,N),M=1,NQS),N=1,NPTS)
000034 IF(NQS.LT.13) GO TO 160
000035 DO 150 N=13,NQS
000036 OUT(K,N-12) =QUAL(J,N)
000037 FLOWOT(K)=FLOW(J)
000038 NHR(K)=NTIMEH
000039 TIMEH(K)=TIMEH
000040 160 CONTINUE
000041 NLT=12
000042 IF(NLT.GT.NQS) NLT=NQS
000043 WRITE(6,6005) NTIMEH,TIMEH,(FLOW(J),QUAL(J,N),N=1,NLT)
000044 6005 FORMAT(14,F9.2,F9.2,3F9.1,F9.2,F9.1,3F9.2,1P2E9.2,0P2F9.2)
000045 190 CONTINUE
000046 192 CONTINUE
000047 IF(NQS.LT.13) GO TO 200
000048 WRITE(6,6030) TITLE,IPRNT(J)
000049 6030 FORMAT( 1H1 / 10X, 20A4 / 10X, 'SUMMARY OF QUANTITY AN
10 QUALITY RESULTS AT LOCATION',15// 10X, 'FLOW IN CFS AND QUALITY I
2N (MG/L)',//
3AX,TIME FLOW NQ3=NQ2 T-HYD=P ORTH=PO4 HG CU
4 ZN PB CR CO AS')
000051 NLT=NQS-12
000052 DO 195 K=1,NRD
000053
000054
000055
000056

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WRITE(6,6006) NHH(K),TMIN(K),FLOWOT(K),(OUT(K,N),N=1,NLT)
6006 FORMAT(14,F6.2,13F9.2)
195 CONTINUE
200 CONTINUE
RETURN
300 DO 350 J = 1, NPTS, 10
    MAX = J + 9
    IF( MAX .GT. NPTS ) MAX = NPTS
    WRITE(6,6020) TITLE
    6020 FORMAT(1H / 10X, 20A4 / 10X, 20A4 // 10X, 'SUMMARY OF FLOWS.....'
    'NO QUALITY SIMULATION...')
    WRITE(6,6025) ( IPRNT(K), K = J, MAX )
    6025 FORMAT( / 10X, 10I10 / )
    REWIND NT1
    READ(NT1) TITLE
    READ(NT1) NTX
    READ(NT1) NTX
    DO 330 K = 1, NSTEP
        READ(NT1) NTIMEH,TIMEH,(FLOW(N),N=1,NPTS)
        IF( NTIMEH .EQ. -1 ) GO TO 350
        WRITE(6,6007) NTIMEH,TIMEH,(FLOW(N),N=J,MAX)
    6007 FORMAT (14,F6.2,10F10.2)
    330 CONTINUE
    350 CONTINUE
    300 CONTINUE
RETURN
END

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 *J2 *
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* ELT RHYDRO,1,740423, 59594

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000001 SUBROUTINE RHYDRO(BASIN)
000002 COMMON /TAPES/ INCAT,IOUNIT,JIN(10),JOUT(10),NSCHAI(5)
000003 COMMON NM,NG,NIN,HISTOG,TRAIN,DELT,DELT2,NOM,NOG,NSTEP,TAREA,
000004 1 TIME,TIME2,RI,ROSS,SUMR,SUMI,SUMOFF,SUMST,1ZERONING
000005 COMMON *FLOW(200),*W10TH(200),*AREA(200),*SLOPE(200),*N(200),
000006 1 *STCR(200,3),*LMAX(200),*LMIN(200),*DECAY(200),*DEPTH(200,3),
000007 2 *CON(200,3),*NAMEM(200),*PCIMP(200)
000008 COMMON GFLOW(200),GW10TH(200),GLEN(200),GSLOPE(200),GSI(200),
000009 1 GS2(200),ON(200),ODEPTH(200),GCON(200),NPG(200),DFULL(200),
000010 2 NGUT(200),SUMO(200),*PCIZER
000011 COMMON NTOG(200,10),NGTOG(200,10),NWTOT(10),NGTOT(200)
000012 COMMON RAIN(200,10),NYET(200),NRAIN,NRGAG,NHISTO,1HISTO
000013 COMMON OSUR(200),DELD(200),GIN(200)
000014 COMMON IPRAT(200),ISAVL(200),NPRNT,NSAVE,OUTFLW(200),INTERV,
000015 1 INTCNT,TITLE(40),IPLT(200),ICODE(25),NPLQT
000016 COMMON/NEW/ NAMEG(200),NGIO(200)
000017 COMMON/INFIL/ RAININ(200),DEPIN(200)
000018 COMMON/ABLK/ NOS,CLFREQ,DRYDAY,NPASS,CBVOL,
000019 1 C(200,6),COOT(200,6),PSHED(200,5),POFF(200,25),
000020 2 KLAND(200),DDFACT(5),OFACI(5,24),PBASIN(200),
000021 3 BASIN3(200),CBFACT(24),GOLEN(200)
000022
000023 C**** GENERAL INFORMATION
000024 C
000025 NDIM=200
000026 DO 210 N=1,NDIM
000027 POFF(N,1)=0.0
000028 210 OUTFLW(N)=0.0
000029 READ(5,1005) TITLE
000030 1005 FORMAT(20A4)
000031 READ(5,1000) BASIN,NSTEP, NHR,NMN,DELT,NRGAG
000032 1,PCIZER
000033 1000 FORMAT(2I5,13,I2,F5.1,15,F5.0)
000034 IF(PCIZER.EQ.0.) PCIZER=25.
000035 1ZERON=3000.*FLOAT(NHR)*50.*FLOAT(NMN)
000036 WRITE(6,1010) TITLE,BASIN,NSTEP
000037 1010 FORMAT(1H1,
000038 1' SEATTLE URBAN RUNOFF AND BASIN DRAINAGE STUDY',40X,
000039 2' WATER RESOURCES ENGINEERS, INC.',/
000040 3' MODIFIED EPA SURFACE RUNOFF MODEL',58X,
000041 4' WALNUT CREEK, CALIFORNIA',/
000042 5,2H ,20A4,2H ,20A4//
000043 6,10BASIN NUMBER',15,10NUMBER OF TIME STEPS',15)
000044 WRITE(6,1041) DELT
000045 1041 FORMAT(10INTEGRATION TIME INTERVAL (MINUTES)',F8.2)
000046 WRITE(6,1043) PCIZER
000047 1043 FORMAT(1H0,F4.1,' PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEIPA
000048 1PTH)
000049
000050 C**** RAINFALL INTENSITY HISTOGRAM
000051 C
000052 READ(5,1020) NHISTO,THISTO
000053 1020 FORMAT(15,F5.0)
000054 WRITE(6,1040) NHISTO,THISTO
000055 1040 FORMAT(10FOR',16,' RAINFALL STEPS, THE TIME INTERVAL IS',
000056 1,F7.2,' MINUTES')

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000057 TRAIN=FLOAT(NHISTO)*THISTO*60.+IZERO
000058 DO 230 N=1,NRGAG
000059 READ(5,1030) (RAIN(I,N),I=1,NHISTO)
000060 1030 FORMAT(10F5.0)
000061 C
000062 C***** PRINT RAINFALL HISTORY
000063 WRITE(6,1042) N,(RAIN(I,N),I=1,NHISTO)
000064 1042 FORMAT(10FOR RAINAGE NUMBER,14,1 RAINFALL HISTORY IS
000065 1,/(10F10.2))
000066 DO 220 I=1,NHISTO
000067 220 RAIN(I,N)=RAIN(I,N)/43200.
000068 230 CONTINUE
000069 THISTO = THISTO*60.
000070 DELT = DELT*60.
000071 DELT2 = DELT/2.
000072 C
000073 C***** GUTTER AND PIPE DATA
000074 C
000075 DO 480 N=1,NG
000076 HEAD (5,1115) NAMEG(N),NGTO(N),NP,G1,G2,G3,G4,G5,G6,G7
000077 1115 FORMAT(2I6,13,5X,7F8.0)
000078 IF(NAMEG(N).EQ.0) GO TO 500
000079 IF( MOD(N,50) .EQ. 1 ) WRITE(6,1110)
000080 1110 FORMAT(1H / 10X, INPUT DATA FOR GUTTERS AND PIPES' // 4X,
000081 1 'INT GUT GUT WIDTH LENGTH SLOPE SIDE SL
000082 20PE8 MANNING DEPTH V FULL Q FULL' / 4X,
000083 3 'NUM NUM CONN (FT) (FT) (CFS)' )
000084 41GHT N (FT) (FPS)
000085 C----- COMPUTE V FULL AND Q FULL.....
000086 C=
000087 IF( NP .EQ. 2 ) GO TO 307
000088 GA = G7 * ( G1 + 0.5 * G7*( G4 + G5 ) )
000089 GP = G1 + G7 * ( SQRT( 1.0 + G4 ** 2 ) + SQRT( 1.0 + G5 ** 2 ) )
000090 GO TO 309
000091 307 GA = 0.7854 * G1 ** 2
000092 CP = 3.14159 * G1
000093 309 GR = GA / GP
000094 GV = 1.486/G6*SQRT(G3)*GR**0.6666667
000095 GQ = GA*GV
000096 C
000097 C***** PRINT GUTTER/PIPE DATA
000098 WRITE(6,1120) N,NAMEG(N),NGTO(N),G1,G2,G3,G4,G5,G6,G7
000099 1 ,GV,GQ
000100 1120 FORMAT(3I7,F10.2,F10.0,F10.5,2F10.1,F10.3,2F10.1,F10.0)
000101 IF(NP.EQ.2) WRITE(6,1122)
000102 1122 FORMAT( 1H+,13X,1H+ )
000103 C
000104 C***** TRANSFER DATA AND CONVERT UNITS
000105 NPG(N)=NP
000106 G1DTH(N)=G1
000107 GLEN(N)=G2
000108 GSLOPE(N)=G3
000109 CS1(N)=G4
000110 CS2(N)=G5
000111 GN(N)=G6
000112 DFULL(N)=G7
000113 IF(NP.EQ.2) DFULL(N)=2.62
000114 IF(DFULL(N).LE.0.) DFULL(N)=10.
000115 GCON(N)=(1.486/GN(N))*SQRT(GSLOPE(N))
000116

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RHYD 39
RHYD 40
RHYD 41

RHYD 47

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RHYD 126
RHYD 127

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RHYD 140

RHYD 143

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RHYD 151
RHYD 152
RHYD 153
RHYD 154

RHYD 156
RHYD 157
RHYD 158

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000177 IF(M11.EQ.0) M11=0.0M15
000178 IF(M12.EQ.0) M12=12.
000179 IF(JA.EQ.0) JA=1
000180 IF(NAME(N).EQ.0) GO TO 360
000181
000182 C***** PRINT WATERSHED DATA
000183 WRITE(6,1070) N,NAME(N),NGTO(N),M1,M2,M3,M4,M5,M6,M7,M8,M9,M10,
000184 M11,M12,JK
000185 1070 FORMAT(14,I8,17,F8.0,F8.2,F7.0,F10.3,F9.2,F11.2,F8.2,F10.5,F7.2,
000186 I4)
000187
000188 C***** TRANSFER DATA AND CONVERT UNITS
000189 NAMEI(N)=JK
000190 ALDI(N)=M1
000191 AREA(N)=M2*43560.
000192 PCIMP(N)=M3
000193 MSLOPE(N)=M4
000194 MSTORE(N,1)=M7/12.
000195 MSTORE(N,2)=M8/12.
000196 MMAX(N)=M9/43200.
000197 MMIN(N)=M10/43200.
000198 DECAY(N)=M11
000199 DEPIN(N)=M12
000200 MCON(N,1)=(1.486/M5)*SQRT(M4)*M1*100./((MAREA(N)*PCIMP(N))
000201 MCON(N,2)=(1.486/M6)*SQRT(M4)*M1*100./((MAREA(N)*PCIMP(N))
000202 MSTORE(N,3)=0.
000203 MCON(N,3)=MCON(N,1)
000204 TAREA=AREA*N2
000205
000206 340 CONTINUE
000207 360 NC=N-1
000208 WRITE(6,1100)NC,TAREA
000209 1100 FORMAT('TOTAL NUMBER OF SUBCATCHMENTS,1,14/
000210 1 INTOTAL TRIBUTARY AREA (ACRES),1,F8.2)
000211
000212 C***** SET UP CONNECTIVITY TABLES
000213 DO 255 N=1,NC
000214 NN=NOG*INLETS
000215 DO 245 NGOTO=1,NN
000216 IF(NGTO(N).EQ. NAME(NGOTO)) GO TO 250
000217 245 CONTINUE
000218 C
000219 C***** IDENTIFY ADDITIONAL INLETS
000220 INLETS=INLETS+1
000221 NGOTO=NOG*INLETS
000222 IF(NGOTO.GT.NG) GO TO 440
000223 NAME(NGOTO)=NGTO(N)
000224 NGC(NGOTO)=3
000225 NGTOI(INLETS)=NGOTO
000226 250 CONTINUE
000227 C***** GUTTER CONNECTION
000228 DO 240 J=1,NN
000229 IF(NOTOG(NGOTO,J).GT.0) GO TO 240
000230 NOTOG(NGOTO,J)=N
000231 GO TO 255
000232 240 CONTINUE
000233 255 CONTINUE
000234 C*** PRINT CONNECTIVITY SUMMARY
000235 C
000236 WRITE(6,1100)

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1190 FORMAT('ARRANGEMENT OF SURCATCHMENTS AND GUTTERS/PIPES',//
11 GUTTER1, 5X, 'TRIBUTARY GUTTER/PIPE1,40X,
21 'TRIBUTARY SUBAREA',//X, 'OR PIPE1)
DO 620 J=1,N0G
DO 605 N=1,NIN
IF(NGTOG(J,N)) 604,606,604
604 INUM=NGTOG(J,N)
NGTO(N)=NAMEG(INUM)
605 CONTINUE
606 N=N+1
IF(N) 607,607,608
607 WRITE(6,1200) NAMEG(J)
GO TO 609
608 WRITE(6,1200) NAMEG(J), (NGTO(K), K=1,N)
1200 FORMAT('110,5X,1015)
609 DO 610 N=1,NIN
IF(NGTOG(J,N)) 611,615,611
611 INUM=NGTOG(J,N)
NGTO(N)=NAMEG(INUM)
613 CONTINUE
615 N=N+1
IF(N) 620,620,616
616 WRITE(6,1230) (NGTO(K), K=1,N)
1230 FORMAT('1H,74X,1015)
620 CONTINUE
WRITE(6,1240)
1240 FORMAT('0 INLET',6X, 'TRIBUTARY GUTTERS AND/OR PIPES',25X,
1 'TRIBUTARY SUBAREA1)
DO 640 I=1,INLETS
NNGTO(I)
JG=0
J=10
DO 630 J=1,NIN
IF(NGTOG(N,J)) 622,625,622
622 JG=JG+1
INUM=NGTOG(N,J)
NGTO(JG)=NAMEG(INUM)
625 IF(NGTOG(N,J)) 627,630,627
627 J=J+1
INUM=NGTOG(N,J)
NGTO(J)=NAMEG(INUM)
630 CONTINUE
WRITE(6,1200) NAMEG(N)
IF(JG.GT.0) WRITE(6,1201) (NGTO(J),J=1,JG)
1201 FORMAT('1H,15X,1015)
IF(J.GT.10) WRITE(6,1230) (NGTO(J),J=11,JW)
640 CONTINUE
C
NSAVE=INLETS
DO 705 J=1,INLETS
NNGTO(J)
ISAVE(J)=NAMEG(N)
705 CONTINUE
WRITE(6,1210) INLETS, (ISAVE(K), K=1,INLETS)
1210 FORMAT('10HYDROGRAPHS WILL BE STORED FOR THE FOLLOWING',15,
11 INLETS',/811H)
C=

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000297 C=.....READ AND WRITE QUALITY INPUTS.....
000298 C-
000299   READ(5,5010) NOS,DRYDAY,CLFREQ,NPASS,CBVOL
000300   5010 FORMAT(10I2,2E10.0,10I10.0)
000301   IF( NOS .GT. 0 ) GO TO 3001
000302   WRITE(6,6010)
000303   6010 FORMAT(/// 10X, '.....QUALITY SIMULATION NOT INCLUDED IN THIS RUN
000304   1.....' )
000305   GO TO 3005
000306   3001 WRITE(6,6020) NOS,DRYDAY,CLFREQ,NPASS,CBVOL
000307   6020 FORMAT(1H1,9X, '.....QUALITY SIMULATION INCLUDED IN THIS RUN.....
000308   1.1 // 10X, 'INPUT PARAMETERS AS FOLLOWS' //
000309   2 10X, 'NUMBER OF CONSTITUENTS', I9 / 10X, 'NUMBER OF DRY DAYS',
000310   3 F12.1 / 10X, 'STREET CLEANING FREQ', F10.1, ' DAYS' /
000311   4 10X, 'PASSES PER CLEANING', I11 / 10X, 'STD CATCH-BASIN VOLUME',
000312   5 F9.2, ' FT3' )
000313   DO 3003 J = 1, NOW
000314   READ(5,5020) N,KL,GO,BA
000315   5020 FORMAT(21I0,2E10.0)
000316   DO 3002 K = 1, NOW
000317   IF( N .NE. NAME*(K) ) GO TO 3002
000318   KLAND(K) = KL
000319   GOLEN(K) = GO
000320   BASINS(K) = BA
000321   3002 CONTINUE
000322   3003 CONTINUE
000323   WRITE(6,6030) ( J,KLAND(J),GOLEN(J),BASINS(J),J=1,NOW )
000324   6030 FORMAT(/// 10X, 'WATERSHED QUALITY DEFINITIONS.....' /
000325   1 13X, 'SUBAREA CLASS GUTTER BASINS' //
000326   2 ( 10X, 21I0, 2F10.2 ) )
000327   3005 CONTINUE
000328   600 CONTINUE
000329   READ(5,1204) NPRNT,INTERV
000330   1204 FORMAT(2I5)
000331   IF(NPRNT.LT.1) GO TO 680
000332   READ (5,1205) (IPRNT(K), K=1,NPRNT)
000333   1205 FORMAT (16I5)
000334   WRITE(6,1220) (IPRNT(K),K=1,NPRNT)
000335   1220 FORMAT(10HYDROGRAPHS AND POLLUTOGRAPHS WILL BE LISTED FOR THE FOLL
000336   10ING GUTTERS OR INLETS, //
000337   21 LOCATION 1,10110/(10X,10110))
000338   680 CONTINUE
000339   READ(5,1204) NPLT
000340   IF(NPLT.EQ.0) GO TO 690
000341   HEAD(5,1205) (IPLOT(K),K=1,NPLT)
000342   READ(5,1206) (ICODE(K),K=1,25)
000343   WRITE(6,1245) (IPLOT(K),K=1,NPLT)
000344   WRITE(6,1250) (ICODE(K),K=1,25)
000345   1245 FORMAT(25I1)
000346   1250 FORMAT(10HYDROGRAPHS AND POLLUTOGRAPHS WILL BE PLOTTED FOR THE FOL
000347   10ING GUTTERS OR INLETS, // LOCATION 1,10110/(10X,10110))
000348   1250 FORMAT(10 PLOT CODES ARE',/1X,25I2)
000349   690 CONTINUE
000350 C=.....SETUP OUTPUT FILES
000351 C-
000352   NSTP=NSTEP+1
000353   NOT=NOS
000354   IF(OUT.EQ.0) NOT=1
000355   DO 860 J=1,4
000356

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STEVE,526388,1.50

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000357 IF(JOUT(J),L1,1) GO TO 860
000358 NTX = JOUT(J)
000359 RE=ND NTX
000360 WRITE(NTX) TITLE
000361 IF(J-3) 825,840,850
000362 *RITE(NTX) NSTP,INLETS,NOS,DELT,TZERO,TAREA
000363 *RITE(NTX) (ISAVE(K),K=1,INLETS)
000364 IF(J-1) GO TO 838
000365 *RITE(NTX) TZERO,(OUTFL(K),K=1,INLETS)
000366 GO TO 860
000367 *RITE(NTX) TZERO,(OUTFL(K),K=1,INLETS),((POFF(K,N),N=1,6),K=1,
000368 1 INLETS)
000369 GO TO 860
000370 *RITE(NTX) NSTP,IPRNT,NOS,DELT,TZERO,TAREA
000371 *RITE(NTX) (IPRNT(K),K=1,NPRNT)
000372 XMIN=XN
000373 *RITE(NTX) NHR,XMIN,(OUTFL(K),K=1,NPRNT)
000374 *RITE(NTX) NHR,XMIN,((POFF(K,N),N=1,NOT),K=1,NPRNT)
000375 GO TO 860
000376 *RITE(NTX) NSTP,NPLOT,NOS,DELT,TZERO,TAREA
000377 *RITE(NTX) (IPLOT(K),K=1,NPLOT)
000378 *RITE(NTX) TZERO,(OUTFL(K),K=1,NPLOT),((POFF(K,N),N=1,NOT),
000379 1 K=1,NPLOT)
000380 860 CONTINUE
000381 C
000382 C***** CONVERT IPRNT TO INTERNAL NUMBERS
000383 IF(IPRNT.EQ.0) GO TO 730
000384 DO 720 N=1,NPRNT
000385 NM=NOS*INLETS
000386 DO 710 J=1,NM
000387 IF (IPRNT(N).EQ.NAMEG(J)) GO TO 715
000388 710 CONTINUE
000389 WRITE (6,712) IPRNT(N),N,NAMEG(J),J
000390 712 FORMAT (1 ERROR - - CANNOT MATCH IPRNT(N),15,1 FOR N=15,1 AND
000391 NAMEG(J),15,1 FOR J=15)
000392 STOP
000393 715 IPRNT(N)=J
000394 720 CONTINUE
000395 730 CONTINUE
000396 C
000397 IF(NPLOT.EQ.0) GO TO 770
000398 NM=NOS*INLETS
000399 DO 760 N=1,NPLOT
000400 DO 750 J=1,NM
000401 IF(IPLOT(N).EQ.NAMEG(J)) GO TO 755
000402 750 CONTINUE
000403 1260 WRITE(6,1260) IPLOT(N)
000404 1260 FORMAT(1 ERROR - - CANNOT MATCH PLOT REQUEST,15,1 WITH GUTTER)
000405 STOP
000406 755 IPLOT(N)=J
000407 760 CONTINUE
000408 770 CONTINUE
000409 C
000410 RETURN
000411 END

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RHYD277
 RHYD280
 RHYD281

• ELT WSHED,1,740213, 61262

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010001 SUBROUTINE WSHED
010002 C
010003 C THIS SUBROUTINE COMPUTES THE INSTANTANEOUS WATER DEPTH
010004 C AND FLOW RATE FOR THE WATERSHED AREAS
010005 C
010006 C***** SPECIFICATION STATEMENTS
010007 C
010008 COMMON N,NG,NIN,HISTOG,IPAIN,DELT,DELT2,ND,ANG,ANGLE,AREA,
010009 C TIME,TIME2,RI,FI,LOSS,SUM,ISUM,ISUMOFF,SUMST,IZERO,NING
010010 C COMMON WFLOW(200),WIDITH(200),WAREA(200),WSLOPE(200),WEN(200),
010011 C WSTORE(200),WLMAX(200),WLMIN(200),WDEPTH(200),J),
010012 C WCON(200),J),NAMEW(200),PCIMP(200)
010013 C COMMON GFLOW(200),GWIDITH(200),GLEN(200),GSLOPE(200),GS1(200),
010014 C GS2(200),GNI(200),GDEPTH(200),GCON(200),NPG(200),DFULL(200),
010015 C NGUT(200),SUMGW(200),PCTZER
010016 C COMMON NRTOG(200,10),NGTGG(200,10),NATOI(10),NGTOI(200)
010017 C COMMON RAIN(200,10),NHYET(200),NRAIN,NRGAG,NHISTO,IMHISTO
010018 C COMMON OSUR(200),DELO(200),QIN(200)
010019 C COMMON IPHNT(200),ISAVE(200),NPRNT,NSAVE,OUTFLW(200),INTERV,
010020 C INTENT
010021 C COMMON/INFIL/ RAININ(200),DEPIN(200)
010022 C
010023 C***** SELECT AVERAGE RAINFALL DURING TIME INTERVAL
010024 C
010025 C IND=1.+(TIME2-IZERO)/HISTOG
010026 C
010027 C***** BEGIN MAJOR LOOP FOR WSHED
010028 C
010029 C DO 320 J=1,NOW
010030 C RI=0.
010031 C NGAG=NHET(J)
010032 C IF(TIME2-LE,TRAIN) RI=RAIN(IN,NGAG)
010033 C DELR=0.
010034 C WFLOW(J)=0.
010035 C IF(WAREA(J).EQ.0.) GO TO 320
010036 C DO 315 K=1,3
010037 C IF(K-2) 201,205,210
010038 C 201 WAW=WAREA(J)*PCIMP(J)/10000.+(100.-PCTZER)
010039 C RLOSS=0.
010040 C GO TO 220
010041 C 205 WAW=WAREA(J)*(100.-PCIMP(J))/100.
010042 C IF(RAININ(J).LT.DEPIN(J))GO TO 206
010043 C RLOSS = 0.0
010044 C GO TO 220
010045 C 206 RLOSS = WLMIN(J)
010046 C GO TO 215
010047 C 210 WAW=WAREA(J)*PCIMP(J)/10000.+PCTZER
010048 C RLOSS=W.
010049 C GO TO 220
010050 C
010051 C***** COMPUTE AVERAGE INFILTRATION DURING TIME INTERVAL
010052 C
010053 C 215 EXPON=DECAY(J)*TIME2
010054 C IF(EXPON.LT.60.) RLOSS=RLOSS+(WLMAX(J)-WLMIN(J))/EXP(EXPON)
010055 C IF((RI-RLOSS)*DELT+WDEPTH(J,K).GT.0.) GO TO 220
010056 C

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SIEVE, 5263M8, 1, 50

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000057 C***** INFILTRATION LOSS EXCEEDS AVAILABLE WATER
000058 RLOSS=RI*DEPTH(J,K)/DELT
000059 *DEPTH(J,K)=0.
000060 *FLO=0.
000061 GO TO 310
000062 C***** COMPUTE CHANGE IN DEPTH (NEWTON-RAPHSON)
000063 C
000064 C
000065 220 IF((RI-RLOSS)*DELT+DEPTH(J,K).LT.*STORE(J,K)) GO TO 245
000066 DO 260 I=1,11
000067 DM=DEPTH(J,K)-*STORE(J,K)+0.5*DELT
000068 IF(DM.LT.0.) DM=0.
000069 F=DELT-DELT*(CON(J,K)*DM+1.6666667*(RI-RLOSS))
000070 DF=1.-DELT*(3.83333333*CON(J,K)*DM+3.6666667)
000071 DELT=DELT+DF
000072 IF(1.EQ.0) GO TO 242
000073 IF((ABS(DELT-DELT)).LT.(ABS(0.01*DELT))) GO TO 280
000074 240 DELT=DELT
000075 260 CONTINUE
000076 IF(DELT.LT.0.001*DEPTH(J,K)) GO TO 280
000077 *RI=(6.1088) TIME,J*DEPTH(J,K),DELT
000078 1000 FORMAT (1 CHECK RESULTS. NO CONVERGENCE IN *WSHED*1,F4.0,16
000079 ,2E12.5)
000080 280 DCORR=DEPTH(J,K)+DELT
000081 DELT=0.
000082 C***** AVERAGE FLOW DURING TIME INTERVAL
000083 C
000084 *FLO=(RI-RLOSS)**AR-(DCORR-DEPTH(J,K))**AR/DELT
000085 IF(*FLO.GT.0.) GO TO 290
000086 285 *FLO=0.
000087 DCORR=DEPTH(J,K)+(RI-RLOSS)*DELT
000088 C***** TRANSFER DEPTH FOR NEXT TIME INTERVAL
000089 C
000090 290 *DEPTH(J,K)=DCORR
000091 C***** SUM FOR CONTINUITY CHECK
000092 C
000093 310 SUM=SUM+*I*DELT*AR
000094 SUMI=SUMI+RLOSS*DELT*AR
000095 *FLO=(J)**FLO*(J)+*FLO
000096 C
000097 C***** SUM INFILTRATION LOSS FOR CHECK ON LIMIT OF INFILTRATION
000098 C
000099 RAININ(J) = RAININ(J) + RLOSS*12.*DELT
000100 315 CONTINUE
000101 320 CONTINUE
000102 C
000103 RETURN
000104 END
000105

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END CUR, ISO VERSION 2.14

TRANSPORT BLOCK

The transport block program listing is presented on the following sheets identified as Pages 3 through 47.

STEVE,526308,1.50

* ELT BLKD,1,731128, 28621

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BLOCK DATA
 COMMON /BO/ANORM(26,5),HRNORM(26,5),TNORM(26,5)
 COMMON/LAR/ 111LE(40),XLAR(11),YLAR(6),HORIZ(5),VERT(6)
 C..... NORMALIZED CROSS-SECTIONAL AREA
 DATA ANORM/
 1 8300, 8134, 8374, 8680, 1033, 1423, 1845, 2292, 2759, 3242,
 2 3736, 4237, 4745, 5255, 5763, 6264, 6758, 7241, 7708, 8154,
 3 8576, 8967, 9320, 9626, 9866, 10038,
 4 8008, 8408, 8808, 9208, 9608, 10008, 2408, 2808, 3208, 3608,
 5 4008, 4408, 4808, 5208, 5608, 6008, 6408, 6808, 7208, 7608,
 6 8008, 8408, 8808, 9208, 9608, 10008,
 7 8008, 8408, 8808, 9208, 9608, 10008, 1326, 1757, 2201, 2655, 3118, 3582,
 8 4364, 4542, 4723, 4906, 5087, 5268, 5442, 5611, 5777, 5937, 6091, 6241, 6386, 6526,
 9 6652, 6822, 6956, 7045, 7131, 7213,
 1 8008, 8408, 8808, 9208, 9608, 10008, 1555, 1983, 2408, 2828,
 2 3208, 3708, 4208, 4708, 5158, 5708, 6208, 6608, 7108, 7608,
 3 8350, 8850, 9250, 9650, 9808, 10008,
 4 8308, 873, 9457, 9828, 1271, 1765, 2270, 2775, 3288, 3788,
 5 4278, 4765, 5268, 5748, 6228, 6698, 7168, 7618, 8038, 8398,
 6 8778, 9118, 9418, 9688, 9888, 10008/
 C..... NORMALIZED HYDRAULIC RADIUS
 DATA HRNORM/
 1 8108, 1048, 2452, 3016, 3644, 4824, 5664, 6456, 7204, 7912,
 2 8568, 9176, 9736, 1024, 1070, 1110, 1144, 1174, 1194, 1218,
 3 1217, 1215, 1203, 1178, 1132, 1080,
 4 8008, 8408, 8808, 9208, 9608, 10008, 2408, 2808, 3208, 3608,
 5 4008, 4408, 4808, 5208, 5608, 6008, 6408, 6808, 7208, 7608,
 6 8008, 8408, 8808, 9208, 9608, 10008,
 7 8108, 1048, 2452, 3016, 3644, 4824, 5664, 6456, 7204, 7912,
 8 8573, 9417, 9905, 1036, 1077, 1113, 1143, 1169, 1188, 1202,
 9 1206, 1206, 1195, 1178, 1126, 1080,
 1 8108, 8970, 2160, 3020, 3868, 4658, 5368, 6118, 6768, 7358,
 2 7910, 8548, 9040, 9410, 1008, 1045, 1076, 1115, 1146, 1162,
 3 1186, 1193, 1186, 1162, 1187, 1238,
 4 8108, 8952, 1693, 2730, 3698, 4630, 5608, 6530, 7438, 8228,
 5 8038, 9498, 9992, 1055, 1095, 1141, 1168, 1188, 1206, 1206,
 6 1206, 1205, 1196, 1168, 1127, 1088/
 C..... NORMALIZED SURFACE WIDTH
 DATA TNORM/
 1 3919, 3919, 5426, 6499, 7332, 8008, 8542, 8908, 9130, 9608,
 2 9798, 9928, 9992, 9992, 9928, 9798, 9608, 9330, 9088, 8542,
 3 8008, 7332, 6499, 5426, 3919, 3919,
 4 8008, 8408, 8808, 9208, 9608, 10008, 2408, 2808, 3208, 3608,
 5 4008, 4408, 4808, 5208, 5608, 6008, 6408, 6808, 7208, 7608,
 6 8008, 8408, 8808, 9208, 9608, 10008,
 7 5878, 5478, 4772, 4808, 4028, 4156, 9284, 9412, 9540, 9668,
 8 9798, 9928, 9992, 9992, 9928, 9798, 9608, 9330, 8908, 8542,
 9 8008, 7332, 6499, 5426, 3919, 3919,
 1 2988, 2988, 4330, 5808, 5828, 6420, 6968, 7468, 7910, 8368,
 2 8658, 8968, 9268, 9568, 9738, 9858, 10008, 9858, 9738, 9568, 9268, 8968, 8658,
 3 8968, 8368, 7648, 6420, 5108, 3108,
 4 4908, 4908, 6673, 8208, 9308, 1008, 1008, 1008, 9970, 9948,

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4 9880,,9820,,9670,,9480,,9280,,9040,,8740,,8420,,7980,,7500,
6 .6970,,6370,,5670,,4670,,3420,,3420/
C DATA VERT /4RJUNC,4NTION,4HMATR,4H SUR,4HELEV,4M(FT)/
C DATA TITLE /4H THE,4HRE I,4HS NO,4H MAT,4HERSH,4MED I,
1 4HPUT,4H SU ,4HTHE ,4HPLOT,4HS AR,4HE FO,4HR CA,4HHD M,4HYETC,
2 4HGRAP,4HHS ,4HOR F,4HOR ,4H ,4H CON,4HSTAN,4MT IN,4HFLOW,
3 4H ,4H ,4H T,4HHS ,4HMESS,4HAGE ,4HS T,4HHRDU,4HGN I,
4 4HHE C,4HOURT,4HESY ,4HOF W,4HRE ,4H ,4H /
C DATA HORIZ/4HCLOC,4HK TI,4HME (,4HHOUR,4HS) /
C END

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STEVE,526388,1,50

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• ELT BOUND,1,740419, 42543

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000001 SUBROUTINE BOUND(YDEP,YDEPT,GP,T)
000002 C
000003 C THIS SUBROUTINE COMPUTES THE OUTFLOW FROM FOR
000004 C EACH NODE: BOTH EXTERNAL & INTERNAL TRANSFERS
000005 C
000006 C COMMON /BD/ANORM(26,5),HRNORM(26,5),TANORM(26,5)
000007 C
000008 C COMMON/CONTR/ NS,N6,N21,NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
000009 C 1 NJ,NC,NTC,TCYC,NJS,NJSN,TIME,TIME2,AL,A2,A3,A4,A5,A6,A7,M
000010 C
000011 C COMMON/JUNC/Y(200),YT(200),NCHAN(200,8),AS(200),Z(200),QIN(200),
000012 C 1 QOUT(200),QINST(200),GRSL(Y(200),JUN(200),ZCRON(200),JSKIP(200)
000013 C 2 ,SUMAL(200)
000014 C
000015 C COMMON/PIPE/LEN(200),NJUNC(200,2),AFULL(200),AT(200),ROUCH(200),
000016 C 1 Q(200),AV(200),VT(200),YDEP(200),A(200),YDE(200),RFULL(200),
000017 C 2 NKCLASS(200),ZP(200,2),G(200),QO(200),H(200,2),NCOND(200)
000018 C
000019 C REAL LEN
000020 C
000021 C DIMENSION YDEP(200),YDEPT(200),GP(200)
000022 C
000023 C COMMON/ORF/ NORIF,LOHIF(60),AORIF(60),F0RIF(60)
000024 C COMMON/WEIR/ NWEIR,LWEIR(60),KWEIR(60),TIDPI(60),YCHEST(60),
000025 C 1 WLEN(60),COEF(60),CORF(60)
000026 C COMMON/PUMP/ NPUMP,LPUHP(20),PRATE(20,3),YRATE(20,3),VVELL(20),
000027 C 1 JPEUL(20)
000028 C COMMON/BND/ NFREE,JFREE(25),NTIDE,JTIDE(25),NGATE,JGATE(25)
000029 C
000030 C HTIDE=-9999.
000031 C
000032 C DO 100 J=1,NJ
000033 C 100 QOU(J)=0.
000034 C
000035 C ..... COMPUTE NEW ELEVATION OF TIDE
000036 C GO TO (110,109,108,128), NTIDE
000037 C 108 HTIDE=A1+A2*SIN(PI)*A3*SIN(2.***T)+A4*SIN(3.***T)
000038 C 1 +A5*COS(PI)+A6*COS(2.***T)+A7*COS(3.***T)
000039 C GO TO 110
000040 C 109 HTIDE=A1
000041 C 110 CONTINUE
000042 C
000043 C ..... COMPUTE DISCHARGE THROUGH ORIFICES
000044 C IF(NORIF)200,200,128
000045 C 120 DO 100 I=1,NORIF
000046 C LINK=LORIF(I)
000047 C DIR=1.
000048 C J1=NJUNC(LINK,1)
000049 C J2=NJUNC(LINK,2)
000050 C Y1=YDEP(J1)
000051 C M1=YDEP(J1)*Z(J1)
000052 C M2=YDEP(J2)*Z(J2)
000053 C ..... CHECK FOR BACKFLOW
000054 C IF(M1-M2) 140,180,160
000055 C 140 J1=J2
000056 C J2=NJUNC(LINK,1)

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STEVE,526308,1,50

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000057 DIR=-1.
000058 V1=YDEP(J2)
000059 IF(HEAD*MINI(Y1,ABS(H1-H2)))
000060 IF(HEAD*LT. 0) HEAD=0.0
000061 AREA=ADHIF(I)
000062 DIA=2.*SORT(AREA/J,141592)
000063 IF(Y1-DIA) 165,170,178
000064 165 FDEPTH=Y1/DIA
000065 K=1+IFX(FDEPTH/0.04)
000066 DELTA=(FDEPTH-0.04*FLOAT(K-1))/0.04
000067 AREA=AREA*(ANORM(K,1)+(ANORM(K+1,1)-ANORM(K,1))*DELTA)
000068 170 QORIF=QORIF(I)*AREA*SQRT(64.4*HEAD)
000069 QP(LINK)=DIR*QORIF
000070 180 CONTINUE
000071
000072 C
000073 C***** COMPUTE DISCHARGE OVER TRANSVERSE AND SIDEFLOW WEIRS
000074 200 IF(NWEIR) 500,500,220
000075 220 DO 500 I=1,NWEIR
000076 C***** INITIALIZE
000077 WK=CCDEF(I)
000078 POWER=1.5
000079 V2=0.0
000080 LINK=LWEIR(I)
000081 DIR=1.
000082 J1=JUNC(LINK,1)
000083 J2=JUNC(LINK,2)
000084 Y1=YDEP(J1)
000085 IF(J2) 240,240,260
000086 240 Y2=MAX1((HTIDE-2(J1)),YCREST(I))
000087 HEAD=Y1-YCREST(I)
000088 IF(HEAD) 480,480,320
000089 260 Y2=YDEP(J2)
000090 HEAD=MAX1(Y1,Y2)-YCREST(I)
000091 IF(HEAD) 480,480,280
000092 C***** CHECK FOR BACKFLOW
000093 280 IF(Y1-Y2) 300,320,320
000094 300 DIR=-1.
000095 Y1=Y2
000096 Y2=YDEP(J1)
000097 J1=J2
000098 J2=JUNC(LINK,1)
000099 C*****CHECK FOR SURCHARGE
000100 320 IF(Y1.GT. YTOP(I)) GO TO 440
000101 IF(DIR) 380,340,340
000102 340 IF(KWEIR(I)-3) 380,360,360
000103 C***** WK IS A FUNCTION OF APPROACH VELOCITY FOR SIDEFLOW WEIRS
000104 360 WK=CCDEF(I)
000105 V2=0.0
000106 POWER=1.67
000107 C***** WEIR DISCHARGE
000108 380 QWEIR=WK*WLEN(I)*((HEAD+V2/64.4)**POWER-(V2/64.4)**POWER)
000109 KW=KWEIR(I)
000110 GO TO (420,400,420,400), KW
000111 C***** APPLY ARMCO TIDE GATE CORRECTION
000112 C 400 IF(HTIDE.GE. (YDEP(J1)+2(J1))) GO TO 480
000113 VEL=CCDEF(I)*HEAD**POWER-1.0
000114 HLOSS=(4./32.2)*VEL**2*EXP(-1.15*VEL/SQRT(YTOP(I)-YCREST(I)))
000115 HEAD=HEAD-HLOSS
000116 IF(HEAD.LE.0.) GO TO 480

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STEVE,526308,1,50

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000117 IF((YCREST(I)*Z(J)+HEADW).LE.WTIDE) GO TO 480
000118 QLEIR=COEF(I)*KLEN(I)*HEADW**POWER
000119 C***** APPLY VILLAMONTE CORRECTION FOR A SUBMERGED WEIR
000120 420 HSY2=YCREST(I)
000121 IF((S.LE.0.) GO TO 500
000122 QLEIR=QLEIR*(1.-(HS/HEADW)**POWER)**0.385
000123 GO TO 500
000124 C***** OUTFLOW IN SURCHARGED CONDITION
000125 440 IF(Y1-Y2) 480,480,460
000126 460 HEADW=Y1-AMAX(Y2,YCREST(I))
000127 QLEIR=COEF(I)*KLEN(I)*(YTOP(I)-YCREST(I))*SQRT(64.4*(H**5-V2)
000128 GO TO 500
000129 480 QLEIR=0.
000130 500 QP(LINK)=DIR*QWEIR
000131 560 CONTINUE
000132 C***** COMPUTE PUMP DISCHARGE
000133 580 IF(CPUMP) 920,920,680
000134 600 DO 900 I=1,NPUMP
000135 LINK=LUMP(I)
000136 J1=NJUNC(LINK,1)
000137 J2=NJUNC(LINK,2)
000138 QINJ=0.0
000139 QINSUM=0.0
000140 C***** SET CONDITIONS FOR WET WELL INFLOW GATES CLOSED
000141 C***** COMPUTE INFLOW TO WET WELL FOR GATE WHEN CONDITION
000142 660 DO 680 K=1,8
000143 N=CHAN(J1,K)
000144 IF (N) 700,700,670
000145 670 QINJ=QINJ+ABS(QP(N))
000146 QINSUM=QINSUM+QP(N)
000147 680 CONTINUE
000148 700 QINJ=QINJ- QP(LINK)
000149 QINSUM=QINSUM-QP(LINK)
000150 VVELL(I)=VVELL(I)+QINJ*DELTA
000151 C***** SET PUMP RATE
000152 720 QOUT=0.0
000153 IF(VVELL(I)) 800,800,740
000154 740 QOUT=PRATE(I,1)
000155 IF(VVELL(I)-VRATE(I,1)) 600,760,760
000156 760 QOUT=PRATE(I,2)
000157 IF(VVELL(I)-VRATE(I,2)) 400,780,780
000158 780 QOUT=PRATE(I,3)
000159 C***** COMPUTE NEW NET WELL VOLUME
000160 800 VNEW=VVELL(I)-QOUT*DELTA
000161 C***** CHECK FOR DRY WELL
000162 JPFUL(I)=1
000163 IF(VNEW) 820,820,840
000164 820 QOUT=VVELL(I)/DELTA
000165 VVELL(I)=0.0
000166 IF (QOUT.LE.0.0) QOUT=0.0
000167 GO TO 890
000168 C***** CHECK FOR FLOODED WELL
000169 840 IF(VRATE(I,3)-VNEW) 860,860,880
000170 860 JPFUL(I)=0
000171 VVELL(I)=VRATE(I,3)
000172 GO TO 890
000173 C***** NORMAL WET WELL CONDITION
000174 880 VVELL(I)=VNEW
000175 890 CONTINUE
000176

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STEVE,526308,1,50

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000177 IF (JPFUL(I)) 891,891,896
000178 891 CONTINUE
000179 RATIO=QOUT/QINSUM
000180 QMULT=AMIN(1.0,RATIO)
000181 DC 894 K=1,8
000182 N=NCNAN(J1,K)
000183 IF (N) 896,896,892
000184 892 QP(N)=QP(N)*QMULT
000185 894 CONTINUE
000186 896 CONTINUE
000187 QP(LINK)=QOUT
000188 900 CONTINUE
000189
000190 C***** SFT DEPTH AT FREE OUTFALL & TIDAL NODES (ONE PIPE/NODE)
000191 920 IF(NFREE) 980,980,940
000192 940 DO 960 I=1,NFREE
000193 J=JFREE(I)
000194 N=NCNAN(J,1)
000195 LINK=NCNAN(J,2)
000196 QP(LINK)=QP(N)
000197 CALL DEPTH(N,NKCLASS(N),QP(N),YCRIT,YNORM)
000198 YDEPT(J)=AMIN(YCRIT,YNORM)
000199 C***** CHECK FOR FULL PIPE OR SURCHARGE
000200 IF(YDEPT(J).GT.DEEP(N)) YDEPT(J)=DEEP(N)
000201 C***** CHECK FOR TIDAL INFLUENCE
000202 IF((YDEPT(J)+Z(J)).LT.HTIDE) YDEPT(J)=HTIDE-Z(J)
000203 960 CONTINUE
000204
000205 C***** SFT DEPTH AT TIDE GATE OR CLOSE GATE
000206 980 IF(NGATE) 1000,1000,1000
000207 1000 DO 1060 I=1,NGATE
000208 J=JGATE(I)
000209 N=NCNAN(J,1)
000210 LINK=NCNAN(J,2)
000211 IF(YDEPT(J)+Z(J)-HTIDE) 1020,1020,1040
000212 C***** GATE CLOSED
000213 1020 JSNIP(J)=0
000214 QP(LINK)=0
000215 GO TO 1060
000216
000217 C***** GATE OPEN: APPLY ARMCO FLAPGATE CORRECTION
000218 C (SEE PAGE 914, ARMCO WATER CONTROL GATE CATALOG)
000219 1040 CALL HYDRAD(N,NKCLASS(N),YDEPT(J),HRAID,AREA,WIDTH)
000220 VEL=QP(J)/AREA
000221 HLOSS=8.*(VEL**2/64.4)*EXP(-1.15*VEL/YSORT(DEEP(N)))
000222 CALL DEPTH(N,NKCLASS(N),QP(N),YCRIT,YNORM)
000223 YDEPT(J)=AMIN(YCRIT,YNORM)
000224 C***** CHECK FOR FULL PIPE OR SURCHARGE
000225 IF(YDEPT(J).GT.DEEP(N)) YDEPT(J)=DEEP(N)
000226 C***** CHECK FOR TIDE ELEVATION
000227 IF((YDEPT(J)+Z(J)).LT.HTIDE) YDEPT(J)=HTIDE-Z(J)
000228 C***** APPLY GATE CORRECTION
000229 YDEPT(J)=YDEPT(J)+HLOSS
000230 JSNIP(J)=1
000231 QP(LINK)=QP(N)
000232 1060 CONTINUE
000233 C 1080 RETURN
000234 END

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• ELT CURVE,1,731128, 28621

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000041 SUBROUTINE CURVE(X,Y,NPT,NCV,NPLOT)
000042 DIMENSION X(202,5),Y(202,5),NPT(5)
000043 1,DUMX(4),DUMY(4)
000044 COMMON/LAB/ALPHA(40),XLAB(11),YLAB(6),HORIZ(5),VERT(5)
000045
000046 SET UP X AND Y SCALES
000047 C
000048 C
000049 XMAX = -1.0E30
000050 XMIN = 1.0E30
000051 YMAX = -1.0E30
000052 YMIN = 1.0E30
000053 DO 100 K = 1, NCV
000054 N = NPT(K)
000055 DO 100 J = 1, N
000056 IF (X(J,K) .GT. XMAX) XMAX = X(J,K)
000057 IF (X(J,K) .LT. XMIN) XMIN = X(J,K)
000058 IF (Y(J,K) .GT. YMAX) YMAX = Y(J,K)
000059 IF (Y(J,K) .LT. YMIN) YMIN = Y(J,K)
000060 100 CONTINUE
000061 DUMX(1) = XMIN
000062 DUMX(2) = XMAX
000063 CALL SCALE(DUMX,10,0,2,1)
000064 DUMY(1) = YMIN
000065 DUMY(2) = YMAX
000066 CALL SCALE(DUMY,5,0,2,1)
000067 DO 120 K = 1, NCV
000068 N = NPT(K)
000069 X(N,1,K) = DUMX(3)
000070 X(N,2,K) = DUMX(4)
000071 Y(N,1,K) = DUMY(3)
000072 Y(N,2,K) = DUMY(4)
000073 120 CONTINUE
000074 C
000075 C
000076 XMIN= DUMX(3)
000077 DELTX= DUMX(4)
000078 XLAB(1)=XMIN
000079 DO 140 I=1,10
000080 140 XLAB(I+1)=XLAB(I)+DELTX
000081 YSCAL=100./(XLAB(11)-XMIN)
000082 C
000083 C
000084 YMIN= DUMY(3)
000085 DELTY= DUMY(4)
000086 YLAB(6)=YMIN
000087 DO 160 I=1,5
000088 160 YLAB(6-I)=YLAB(7-I)+DELTY
000089 YSCAL=50./(YLAB(11)-YMIN)
000090 C
000091 C
000092 NCD=100
000093 CALL PPLOT(0,0,NCD,NPLOT)
000094 K = 1
000095
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VIII-44

STEVE,526308,1,58

• ELT DEPTH,1,740222, 54242

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010001 SUBROUTINE DEPTH(N,NTYPE,OPP,YC,YNORM)
010002 C
010003 C THIS SUBROUTINE FINDS THE CRITICAL DEPTH
010004 C AND THE NORMAL DEPTH CORRESPONDING TO THE FLOW QP
010005 C
010006 C COMMON /BD/ANORM(26,5),HRNORM(26,5),TNORM(26,5)
010007 C
010008 C COMMON/PIPE/LEN(200),NJUNC(200,2),AFULL(200),AT(200),ROUGH(200),
010009 C 1 Q(200),VT(200),DEEP(200),A(200),WIDE(200),HFULL(200),
010010 C 2 NKCLASS(200),ZP(200,2),QT(200),QO(200),H(200,2),FONDO(200)
010011 C REAL LEN
010012 C
010013 C COMMON/TRAP/STHETA(200),SPHY(200)
010014 C
010015 C
010016 C
010017 C
010018 C ***** SEARCH AREA & WIDTH TABLES FOR PROPER LOCATION
010019 C QP=ABS(OPP)
010020 C GO TO (100,700,100,100,100,800),NTYPE
010021 C 100 CONTINUE
010022 C QCO=Q*0
010023 C DO 300 I=2,26
010024 C AREA=AFULL(N)*ANORM(I,NTYPE)
010025 C WIDTH=WIDE(N)*TNORM(I,NTYPE)
010026 C CC=AREA*SQRT(32.2*AREA/WIDTH)
010027 C YF(CC-QP) 250,200,200
010028 C DELTA=(QP-QCO)/(CC-QCO)
010029 C YC=0.84*(FLOAT(I-2)*DELTA)*DEEP(N)
010030 C GO TO 400
010031 C 250 QCO=QC
010032 C 300 CONTINUE
010033 C
010034 C ***** PIPE SURCHARGED AT THIS SECTION
010035 C YC=DEEP(N)
010036 C
010037 C ***** SEARCH AREA & RADIUS TABLES FOR PROPER LOCATION
010038 C 400 QNORM=0
010039 C DO 600 I=2,26
010040 C AREA=AFULL(N)*ANORM(I,NTYPE)
010041 C HRAD=FULL(N)*HRNORM(I,NTYPE)
010042 C QNORM=SQRT(32.2*(ZP(N,1)-7*P(N,2))/(LEN(N)*ROUGH(N)))
010043 C ! *AREA*HRAD**0.6667
010044 C IF (QNORM-QP) 550,500,500
010045 C 500 DELTA=(QP-QNORM)/(QNORM-QNORMO)
010046 C YNORM=0.84*(FLOAT(I-2)*DELTA)*DEEP(N)
010047 C RETURN
010048 C 550 QNORMO=QNORM
010049 C 600 CONTINUE
010050 C ***** PIPE SURCHARGED AT THIS SECTION
010051 C YNORM=DEEP(N)
010052 C RETURN
010053 C 700 CONTINUE
010054 C
010055 C ***** YC AND YNORM COMPUTED FOR RECTANGULAR CHANNEL
010056 C QCO=0*0

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STEVE,526308,1,50

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010057 DO 750 I=2,26
010058 AREA=AFULL(N)*ANORM(I,NTYPE)
010059 WIDTH=WIDTH(N)
010060 QC=AREA*SQRT(32.2*AREA/WIDTH)
010061 IF (QC-QP) 740,710,710
010062 DELTA=(QP-QC)/(QC-QC)
010063 YC=0.04*(FLUAT(1-2)*DELTA)*DEEP(N)
010064 GO TO 760
010065 740 QCO=QC
010066 750 CONTINUE
010067 YC=DEEP(N)
010068 760 QNORM=0.0
010069 DO 780 I=2,26
010070 AREA=AFULL(N)*ANORM(I,NTYPE)
010071 HRAO=AREA/(WIDE(N)+2.0*DEEP(N)*0.84*FLOAT(I-1))
010072 QNORM=SQRT(32.2*(ZP(N,1)-ZP(N,2))/(LEN(N)*ROUGH(N)))
010073 I=AREA*HRAO**0.6667
010074 IF (QNORM-QP) 770,765,765
010075 DELTA=(QP-QNORM)/(QNORM-QNORM)
010076 YNORM=0.04*(FLOAT(I-2)*DELTA)*DEEP(N)
010077 RETURN
010078 770 QNORM=QNORM
010079 780 CONTINUE
010080 C***** PIPE SURCHARGED AT THIS SECTION
010081 YNORM=DEEP(N)
010082 RETURN
010083 C
010084 C***** YC AND YNORM COMPUTED FOR TRAPEZOIDAL CHANNEL
010085 800 CONTINUE
010086 QCO=0.0
010087 DO 850 I=2,26
010088 DTEMP=J.04*FLOAT(I-1)*DEEP(N)
010089 AREA= DTEMP*(WIDE(N)+DTEMP/2.0*(STHETA(N)*SPHI(N)))
010090 WIDTH=DTEMP*(STHETA(N)*SPHI(N))+WIDE(N)
010091 QC=AREA*SQRT(32.2*AREA/WIDTH)
010092 IF (QC-QP) 840,810,810
010093 DELTA=(QP-QC)/(QC-QC)
010094 YC=0.04*(FLOAT(I-2)*DELTA)*DEEP(N)
010095 GO TO 860
010096 840 QCO=QC
010097 850 CONTINUE
010098 YC=DEEP(N)
010099 QNORM=0.0
010100 SROOTS=SQRT(1.+STHETA(N)**2.)*SQRT(1.+SPHI(N)**2.)
010101 DO 880 I=2,26
010102 DTEMP=0.04*FLOAT(I-1)*DEEP(N)
010103 AREA= DTEMP*(WIDE(N)+DTEMP/2.0*(STHETA(N)*SPHI(N)))
010104 HRAO=AREA/(WIDE(N)+DTEMP*ROOTS)
010105 QNORM=SQRT(32.2*(ZP(N,1)-ZP(N,2))/(LEN(N)*ROUGH(N)))
010106 I=AREA*HRAO**0.6667
010107 IF (QNORM-QP) 870,865,865
010108 DELTA=(QP-QNORM)/(QNORM-QNORM)
010109 YNORM=0.04*(FLOAT(I-2)*DELTA)*DEEP(N)
010110 RETURN
010111 870 QNORM=QNORM
010112 880 CONTINUE
010113 YNORM=DEEP(N)
010114 RETURN
010115 END

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• ELT HEAD,1,740531, 36044

• SUBROUTINE HEAD(N,NL,NH,HEAD1,HEAD2,OP,AREA,VEL,HEAD,ANH,ANL,RNL)

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      THIS SUBROUTINE CONVERTS NODAL DEPTHS TO PIPE DEPTHS
      IT ALSO ASSIGNS SURFACE AREA TO THE PROPER NODES

      COMMON/JUNC/YI(200),YI(200),NCHAN(200,9),AS(200),Z(200),ZIN(200),
      1 QOU(200),QOIN(200),GHELEV(200),JUNC(200),ZCHOWN(200),JSKIP(200)
      2 ,SUMAL(200)

      COMMON/PIPE/LEN(200),NJUNC(200,2),AFULL(200),AT(200),ROUGH(200),
      1 Q(200),V(200),VT(200),DEEP(200),A(200),ATDE(200),RFULL(200),
      2 NKCLASS(200),ZP(200,2),OT(200),QC(200),H(200,2),NCOND(200)
      REAL LEN

      YNL=HEAD1-ZP(N,1)
      YNH=HEAD2-ZP(N,2)

      C***** CHECK FOR DRY PIPE
      IF (YNL.LE.0.AND.YNH.LE.0.) GO TO 228
      IF (YNL) 10,10,20
      C***** YNL.LE.0, YNH.GT.0 (CRIT OR NORM UPSTRM OR STORAGE DOWNSTRM)
      10 IF (HEAD2-ZP(N,1)) 240,15,15
      15 IF (ZP(N,1).LE.Z(NL)) GO TO 160
      CALL DEPTH(N,NKCLASS(N),OP,YC,YNORM)
      GO TO 240
      C***** YNH.LE.0, YNL.GT.0, CRITICAL OR NORM DOWNSREAM
      20 IF (YNH) 25,25,30
      25 IF (ZP(N,2).LE.Z(NH)) GO TO 160
      CALL DEPTH(N,NKCLASS(N),OP,YC,YNORM)
      Y2=AMINI(YC,YNORM)
      GO TO 180
      C***** YNL AND YNH GT 0
      30 IF (UP) 35,50,50
      C***** ADVERSE FLOW
      35 IF (ZP(N,1)-Z(NL)) 160,160,40
      40 CALL DEPTH(N,NKCLASS(N),OP,YC,YNORM)
      IF (YC-YNL) 160,160,200
      C***** POSITIVE FLOW
      50 IF (ZP(N,2)-Z(NH)) 160,160,55
      55 CALL DEPTH(N,NKCLASS(N),OP,YC,YNORM)
      Y2=AMINI(YC,YNORM)
      IF (Y2-YNH) 120,120,180
      120 IF (YNH-AMAX1(YC,YNORM)) 140,140,160
      140 FASH=(YNH-Y2)/ABS(YNORM-YC)
      GO TO 165
      C***** NORMAL SITUATION: HALF SURFACE AREA AT EACH END
      160 FASH=1.0
      165 YMID=0.5*(YNL+YNH)
      IF (YMID.LT.0.0) YMID=0.0
      CALL HYDRAD(N,NKCLASS(N),YNL,RNL,ANL,BNL)
      CALL HYDRAD(N,NKCLASS(N),YMID,RMID,AMID,BMID)
      CALL HYDRAD(N,NKCLASS(N),YNH,RNH,ANH,BNH)
      AS(NL)=AS(NL)*0.25*(BNL+BMID)*LEN(N)
      AS(NH)=AS(NH)*0.25*(BNH+BMID)*LEN(N)

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STEVE, 526388, 1, 50

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AS(NH)=AS(NH)+0.25*(BMID*BNH)*LEN(N)*FASNH
GO TO 260

C***** CRITICAL SECTION DOWNSTREAM: SURFACE AREA UPSTREAM
180 YNHY2
HEAD2=YNH+ZP(N,2)
YHID=0.5*(YNL+YNH)
IF (YHID.LT.0.0) YHID=0.0
CALL HYDRAD(N,NKLASS(N),YNL,RNL,ANL,BNL)
CALL HYDRAD(N,NKLASS(N),YHID,RHID,AMID,BMID)
CALL HYDRAD(N,NKLASS(N),YNH,RNH,ANH,BNH)
AS(NL)=AS(NL)+0.25*(BNL+BMID)*LEN(N)
GO TO 260

C***** CRITICAL SECTION UPSTREAM: SURFACE AREA DOWNSTREAM
200 HEAD1=YC+ZP(N,1)
YNLYC
YHID=0.5*(YNL+YNH)
IF (YHID.LT.0.0) YHID=0.0
CALL HYDRAD(N,NKLASS(N),YNL,RNL,ANL,BNL)
CALL HYDRAD(N,NKLASS(N),YHID,RHID,AMID,BMID)
CALL HYDRAD(N,NKLASS(N),YNH,RNH,ANH,BNH)
AS(NH)=AS(NH)+0.25*(BMID*BNH)*LEN(N)
GO TO 260

C***** DRY PIPE: NO SURFACE AREA
220 HEAD1=HEAD2
YNL=0.
YHID=0.
CALL HYDRAD(N,NKLASS(N),YHID,RHID,AMID,BMID)
IF (ZP(N,1).LE.Z(NL)) AS(NL)=AS(NL)+BMID*LEN(N)/2.
IF (ZP(N,2).LE.Z(NH)) AS(NH)=AS(NH)+BMID*LEN(N)/2.
AREA=0.
VEL=0.
GO(N)=0.0
HRAD=-.01
RETURN

C***** DRY UPSTREAM: SURFACE AREA DOWNSTREAM
240 HEAD1=HEAD2
YNL=0.
YHID=HEAD2-W.5*(ZP(N,1)+ZP(N,2))
IF (YHID.LT.0.0) YHID=0.0
CALL HYDRAD(N,NKLASS(N),YNL,RNL,ANL,BNL)
CALL HYDRAD(N,NKLASS(N),YHID,RHID,AMID,BMID)
CALL HYDRAD(N,NKLASS(N),YNH,RNH,ANH,BNH)
IF (ZP(N,1).LE.Z(NL)) AS(NL)=AS(NL)+0.5*(BMID*BNH)*LEN(N)
AS(NH)=AS(NH)+0.25*(BMID*BNH)*LEN(N)
AREA=0.0
VEL=0.0
GO(N)=0.0
HRAD=0.5*(RMID+RNH)
RETURN

C***** COMPUTE CROSS-SECTION AREA, VELOCITY & HYDRAULIC RADIUS
260 AREA=0.25*(ANL+2.*AMID+ANH)
VEL=0.
IF (AREA.GT.0.) VEL=QPI/AREA
IF (AREA.LE.0.0) GO(N)=0.0

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STEVE,526308,1,50
HRAD=0.25*(RNL+2.*RMID+RNP)
RETURN
END

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* ELF HYDRAD,1,740222, 51243

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000001 SUBROUTINE HYDRAD (N,NTYPE,DEPTH,HRAD,AREA,WIDTH)
000002 C
000003 C THIS SUBROUTINE COMPUTES THE HYDRAULIC RADIUS,
000004 C SURFACE WIDTH, & CROSS-SECTION AREA FOR PIPE IN
000005 C
000006 C COMMON /BD/ANORM(26,5),HRNORM(26,5),TNORM(26,5)
000007 C
000008 C COMMON/PIPE/LEN(200),NJUNC(200,2),AFULL(200),AT(200),ROUGH(200),
000009 C 1 Q(200),V(200),VT(200),DEEP(200),A(200),WIDE(200),RFULL(200),
000010 C 2 NKCLASS(200),ZP(200,2),QT(200),QC(200),H(200,2),NCOND(200)
000011 C REAL LEN
000012 C
000013 C COMMON/TRAP/STHETA(200),SPHI(200)
000014 C
000015 C
000016 C
000017 C
000018 C
000019 IF(DEPTH, 200,100,100
000020 100 GO TO (120,180,120,120,120,190),NTYPE
000021 120 FDEPTH=DEPTH/DEEP(N)
000022 IF(FDEPTH-1.) 140,160,160
000023 C
000024 C ***** INTERPOLATE TABLE OF PROPERTIES
000025 140 I=1+IFIX(FDEPTH/0.04)
000026 DELTA=(FDEPTH-0.04*FLOAT(I-1))/0.04
000027 WIDTH=WIDE(N)*TNORM(I,NTYPE)+(TNORM(I+1,NTYPE)-TNORM(I,NTYPE)
000028 1)*DELTA
000029 AREA=AFULL(N)*(ANORM(I,NTYPE)+(ANORM(I+1,NTYPE)-ANORM(I,NTYPE)
000030 1)*DELTA)
000031 HRAD=RFULL(N)*(HRNORM(I,NTYPE)+(HRNORM(I+1,NTYPE)-HRNORM(I,NTYPE)
000032 1)*DELTA)
000033 RETURN
000034 C
000035 C ***** FULL PIPE
000036 160 WIDTH=WIDE(N)*TNORM(26,NTYPE)
000037 AREA=AFULL(N)
000038 HRAD=RFULL(N)
000039 RETURN
000040 C
000041 C ***** RECTANGULAR SECTION (SPECIAL CASE)
000042 C
000043 180 WIDTH=WIDE(N)
000044 DEPTH=DEPTH
000045 FDEP=DEPTH-DEEP(N)
000046 IF (FDEP) 186,186,184
000047 184 DEPTH=DEEP(N)
000048 AREA=WIDE(N)*DEPTH
000049 HRAD=AREA/(2.*(WIDE(N)+DEPTH))
000050 GO TO 188
000051 186 CONTINUE
000052 AREA=WIDE(N)*DEPTH
000053 HRAD=AREA/(WIDE(N)+2.*DEPTH)
000054 188 CONTINUE
000055 HRAD=MAX1(HRAD,0.01)
000056 RETURN
000057 C
000058 C ***** TRAPEZOIDAL SECTION (SPECIAL CASE)
000059 C
000060 1041

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000057 190 CONTINUE
000058   DEPTH=DEPTH
000059   FDEP=DEPTM-DEEP(N)
000060   IF (FDEP) 196,196,194
000061 194 DEPT=DEEP(N)
000062 196 CONTINUE
000063   IDTH=ID(N)+DEPT*(STHETA(N)+SPHI(N))
000064   AREA=DEPT*(ID(N)+DEPT/2)*(STHETA(N)+SPHI(N))
000065   WETPR=AREA/DEPT*(SQRT(1+STHETA(N)**2)+SQRT(1+SPHI(N)**2))
000066   HRAD=AREA/WETPR
000067   HRAD=MAX1(HRAD,0.01)
000068   RETURN
000069
000070 C***** NEGATIVE DEPTH
000071 200 WRITE(6,5000) N,DEPTH
000072 5000 FORMAT('NEGATIVE DEPTH ENTERED TO HYDRAD',I6,E16.4)
000073   DEPTH=0.
000074   GO TO 100
000075   END

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* ELT INDATA,1,740710, 62227

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000001 SUBROUTINE INDATA
000002 C
000003 C THIS SUBROUTINE READS & PRINTS ALL INPUT DATA
000004 C EXCEPT FOR HYDROGRAPH CARDS IN 'INFLOW'
000005 C IT ALSO PERFORMS SOME INITIALIZATION
000006 C ALL NODE-CONDUIT LINKAGES ARE SET UP &
000007 C CONVERTED TO THE INTERNAL NUMBER SYSTEM
000008 C
000009 C COMMON /60/ANORM(26,5),HRNORM(26,5),TNORM(26,5)
000010 C
000011 C COMMON/CONTR/ N5,N6,N21,NTCYC,DELIO,DELT,DEL12,TZERO,ALPHA(30),
000012 C 1 NJ,NC,NTC,ICYC,NJSW,MJSM,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,A
000013 C COMMON/TRNVAL/ N2
000014 C
000015 C COMMON/JUNC/Y(200),YT(200),NCHAN(200,8),AS(200),Z(200),OIN(200),
000016 C 1 ROU(200),GINST(200),GRELEV(200),JUN(200),ZCROWN(200),JSKIP(200),
000017 C 2, SUMAL(200)
000018 C
000019 C COMMON/PIPE/LEN(200),NJUNC(200,2),AFULL(200),AT(200),ROUGH(200),
000020 C 1 U(200),V(200),VT(200),DEEP(200),AI(200),WIDE(200),HFULL(200),
000021 C 2 NKCLASS(200),ZP(200,2),OT(200),OO(200),H(200,2),NCOND(200)
000022 C
000023 C COMMON/TRAP/STHETA(200),SPHI(200)
000024 C
000025 C REAL LEN
000026 C
000027 C COMMON/DRF/ NORIF,LORIF(60),AORIF(60),CORIF(60)
000028 C COMMON/WEIR/ NWEIR,LWEIR(60),KWEIR(60),YTOP(60),YREST(60),
000029 C 1 WLEN(60),COEF(60),COEFS(60)
000030 C COMMON/PUMP/ NPUMP,LPUMP(20),PHATE(20,3),VRATE(20,3),VWELL(20),
000031 C 1 JPFUL(20)
000032 C COMMON/BND/ NFREE,JFREE(25),NTIDE,JTIDE(25),NGATE,JGATE(25)
000033 C
000034 C COMMON/OUT/ NPRT,IPRT,NHPRT,JPRT(20),PRTH(100,20),PRREL(20),
000035 C 1 NPRT,CPRT(20),PRTV(100,20),PRTO(100,20),IDUM(12),ICOL(10),
000036 C 2 LTIME,NPLT,JPLT(20),YPLT(102,20),LPLT,KPLT(20),QPLT(102,20),
000037 C 3 TPLT(102),NPTOT,NSTART,INTER,PRTY(100,20)
000038 C INTEGER CPRT
000039 C
000040 C COMMON/TIDE/ YY(50),TT(50),AA(10),XX(10),SXX(10,10),SXY(10)
000041 C
000042 C COMMON/HYFLOW/ ISW(200),DTAPE(200,2),JSW(20),OCARD(20,2),
000043 C 1 WATSH(200),TEC,TP,T2,TE,T20,TIME0,NSTEPS,NINREC
000044 C
000045 C COMMON/LAB/ TITLE(40),XLAB(11),YLAB(6),HORIZ(5),VERT(6)
000046 C
000047 C COMMON/QUAL/INQUAL
000048 C DIMENSION YES(6),TELL(3)
000049 C DATA YES/4H ***,2*0.0,4H ,2*0.0/
000050 C
000051 C ***** TAPE ASSIGNMENTS
000052 C N5=5
000053 C N6=6
000054 C
000055 C
000056 C

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000117 C
000118 C ***** CONDUIT DATA
000119 C
000120 DO 260 I=1,400
000121 READ (N5,5280) NCOND(N),NJUNC(N,K),K=1,2,NKCLASS(N),AFULL(N)
000122 1,DEEP(N),WIDE(N),LEN(N),(7P(N,K),K=1,2),ROUGH(N),STHETA(N),SPHI(N)
000123 5280 FORMAT (4I5,7F5.0,10X,2F5.0)
000124 IF (NCOND(N).GT.90000) GO TO 280
000125 IF (ROUGH(N).LE. 0.0) ROUGH(N) = 0.014
000126 KCLASS=NKCLASS(N)
000127 NCLASS=1: CIRCULAR PIPE
000128 NCLASS=2: RECTANGULAR PIPE
000129 NCLASS=3: HORSESHOE PIPE
000130 NCLASS=4: EGGSHPED PIPE
000131 NCLASS=5: HASKETHANDLE PIPE
000132 NCLASS=6: TRAPEZOIDAL OPEN CHANNEL
000133 GO TO (140,160,180,200,220,230),KCLASS
000134 140 RFULL(N)=DEEP(N)/4.
000135 AFULL(N)=(3.1415926/4.)*DEEP(N)**2
000136 WIDE(N)=DEEP(N)
000137 GO TO 240
000138 160 RFULL(N)=(WIDE(N)*DEEP(N))/(2.*WIDE(N)*2.*DEEP(N))
000139 AFULL(N)=WIDE(N)*DEEP(N)
000140 GO TO 240
000141 180 RFULL(N)=0.25381*DEEP(N)
000142 GO TO 240
000143 200 RFULL(N)=0.19311*DEEP(N)
000144 GO TO 240
000145 220 RFULL(N)=0.28803*DEEP(N)
000146 GO TO 40
000147 230 AFULL(N)=DEEP(N)*(WIDE(N)+DEEP(N)/2.*(STHETA(N)*SPHI(N)))
000148 RFULL(N)=AFULL(N)/( WIDE(N)+DEEP(N)*(SORT(1.+(STHETA(N)**2.))
000149 1+SORT(1.+SPHI(N)**2.)))
000150 240 CONTINUE
000151 260 CONTINUE
000152 280 NC=N-1
000153 NTC=NC
000154 C ***** PRINT CONDUIT DATA
000155 WRITE(N6,5300)
000156 5300 FORMAT(1H1,
000157 1 MAX WIDTH
000158 2 SHAPEZOID//,
000159 3 27X,NUMBER
000160 3 (F1) AT ENDS
000161 NSPRT=1
000162 DO 300 I=1,NC
000163 IF ((7P(N,I).GT.0.).OR.(7P(N,2).GT.0.)) GO TO 285
000164 DO 203 I=1,3
000165 II=I+3
000166 283 TELL(1)=YES(II)
000167 GO TO 295
000168 285 DO 290 I=1,3
000169 TELL(1)=YES(1)
000170 TELL(2)=2P(N,I)
000171 TELL(3)=2P(N,2)
000172 NSPRT=1
000173 295 CONTINUE
000174 WRITE(N6,5320) N,NCOND(N),LEN(N),NCLASS(N),AFULL(N),ROUGH(N),
000175 1,WIDE(N),DEEP(N),(NJUNC(N,K),K=1,2),TELL,STHETA(N),SPHI(N)
000176 5320 FORMAT (14,19,F9.0,17,F12.2,F9.3,F15.2,F13.2,217,14X,A4,

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000177      12X,2F4.1,2F5.2)
000178      300 CONTINUE
000179      IF (NSPT) 310,304,304
000180      304 CONTINUE
000181      WRITE (N6,5330)
000182      5330 FORMAT (/) *** SPECIAL CONDUIT, FEET DIFFERENCE BETWEEN INVER
000183      IT OF NODE AND CONDUIT INVERT AT NODE.1)
000184      310 CONTINUE
000185      C
000186      C***** JUNCTION DATA
000187      C
000188      DO 300 J=1,350
000189      READ (N5,5340) JUN(J),GRELEV(J),Z(J),QINST(J)
000190      5340 FORMAT (15,5F5.0)
000191      IF (JUN(J).GT.98000) GO TO 400
000192      ZERO=N(J)=Z(J)
000193      JSKIP(J)=0
000194      C***** SET UP JUNCTION CONNECTIVITY ARRAY FROM PIPE DATA
000195      C
000196      LOC=1
000197      SUMAL(J)=0.
000198      DO 360 N=1,NC
000199      DO 360 K=1,2
000200      IF (NJUNC(N,K)-JUN(J)) 360,360,360
000201      360 NCHAN(J,LOC)=N
000202      LOC=LOC+1
000203      SUMAL(J)=SUMAL(J)+AFULL(N)/LEN(N)
000204      360 CONTINUE
000205      380 CONTINUE
000206      400 NJ=J-1
000207      NJ1=NJ
000208      C***** PRINT JUNCTION DATA
000209      WRITE (N6,5360)
000210      5360 FORMAT(1H1,5X, JUNCTION      GROUND      INVERT      QINST,15X,1CONNMIR
000211      1ECTING CONDUITS,7X,NUMBER1,7X,ELEV.,6X,ELEV.,5X,1(CFS)1/)
000212      DO 460 J=1,NJ
000213      MPT=0
000214      DO 420 I=1,8
000215      K1 = NCHAN(J,I)
000216      IF (K1.EQ.0) GO TO 440
000217      IDUM(I) = NCOND(K1)
000218      IF (IDUM(I).LE.0) GO TO 440
000219      MPT=MPT+1
000220      420 CONTINUE
000221      440 CONTINUE
000222      WRITE (N6,5380) J,JUN(J),GRELEV(J),Z(J),QINST(J),(IDUM(K),K=1,MPT)
000223      5380 FORMAT(14,19,F12.2,F11.2,F10.2,15X,817)
000224      QINST(J)=DELTA*QINST(J)
000225      460 CONTINUE
000226      480 CONTINUE
000227      C
000228      C***** CONVERT CONDUIT CONNECTIVITY NUMBERS TO INTERNAL SYSTEM
000229      C***** ASSIGN POSITIVE DOWNSTREAM FLOW CONVENTION
000230      C
000231      DO 500 N=1,NC
000232      DO 500 K=1,2
000233      DO 500 J=1,NJ
000234      IF (NJUNC(N,K)-JUN(J)) 500,520,500
000235      500 CONTINUE
000236      520 NJUNC(N,K)=J
000237      540 CONTINUE
000238      NL=NJUNC(N,1)

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000237      NH=NJUNC(N,2)
000238      ZP(4,1)=Z(NL)+ZP(N,1)
000239      ZP(4,2)=Z(NH)+ZP(N,2)
000240      IF(ZP(N,1)-ZP(N,2)) 560,580,580
000241      560 TEMP=ZP(N,1)
000242      ZP(4,1)=ZP(N,2)
000243      ZP(4,2)=TEMP
000244      NJUNC(N,1)=NH
000245      NJUNC(N,2)=NL
000246      NL=NJUNC(N,1)
000247      NH=NJUNC(N,2)
000248      580 IF((ZP(N,1)+DEEP(N)).GT.ZCROWN(NL)) ZCROWN(NL)=ZP(N,1)+DEEP(N)
000249      IF((ZP(N,2)+DEEP(N)).GT.ZCROWN(NH)) ZCROWN(NH)=ZP(N,2)+DEEP(N)
000250      600 CONTINUE
000251      C
000252      C***** CHECK WHETHER ZCROWN(J) IS ABOVE THE GROUND
000253      C
000254      DO 610 J=1,NJ
000255      IF (ZCROWN(J)).IE.GRELEV(J)) GO TO 610
000256      WRITE (6,5390) JUN(J)
000257      5390 FORMAT (' GROUND ELEVATION IS LESS THAN ZCROWN AT NODE',I10)
000258      NSTOP=1
000259      610 CONTINUE
000260      C
000261      C***** ORIFICE DATA
000262      C
000263      DO 620 I=1,60
000264      N=NTC+I
000265      READ(N5,5400) (NJUNC(N,K),K=1,2),AORIF(I),CORIF(I)
000266      5400 FORMAT(2I5,2F5.0)
000267      IF(NJUNC(N,1).GE.90000) GO TO 640
000268      620 CONTINUE
000269      640 NORIF=I-1
000270      C***** PRINT ORIFICE NODES
000271      IF(NORIF) 800,800,600
000272      600 WRITE(N6,5420)
000273      5420 FORMAT('ORIFICE DATA,')
000274      DO 600 I=1,NORIF
000275      N=NTC+I
000276      600 WRITE(N6,5440) 1,(NJUNC(N,K),K=1,2),AORIF(I),CORIF(I)
000277      5440 FORMAT(15,2I10,F12.0,F12.4)
000278      C***** CONVERT TO INTERNAL NUMBER SYSTEM
000279      DO 700 I=1,NORIF
000280      N=NTC+I
000281      LORIF(I)=N
000282      NCONC(N)=N
000283      DO 700 K=1,2
000284      DO 700 J=1,NJ
000285      IF(NJUNC(N,K)-JUN(J)) 700,720,700
000286      700 CONTINUE
000287      720 NJUNC(N,K)=J
000288      DO 740 KK=1,8
000289      IF(NCHAN(J,KK)) 760,760,740
000290      740 CONTINUE
000291      760 NCHAN(J,KK)=N
000292      780 CONTINUE
000293      NTC=NTC+NORIF
000294      800 CONTINUE
000295      C
000296      C***** WEIR DATA (SOME TIDE GATES)

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000297      DO 820 I=1,60
000298      N=NTC+1
000299      READ(N5,5400) (NJUNC(N,K),K=1,2),KWEIR(I),YCREST(I),YTOP(I),
000300      1 *LEN(I),COEF(I),COEFS(I)
000301      5400 FORMAT(3I5,5F5.0)
000302      IF(NJUNC(N,1).GT.90000) GO TO 840
000303      820 CONTINUE
000304      840 N=NTC+1
000305      C***** SET UP NEW NODES FOR INTERNAL WEIRS & HENUMBER
000306      IF(N=1) 1000,1040,860
000307      860 WRITE(N6,5400)
000308      5400 FORMAT ('WEIR DATA.1//')
000309      DO 1020 I=1,NWEIR
000310      N=NTC+1
000311      LWEIR(I)=N1
000312      NCOND(N1)=N1
000313      DO 850 J=1,NJ
000314      IF(NJUNC(N,1)-JUN(J)) 880,900,880
000315      880 CONTINUE
000316      900 IF(NJUNC(N1,2).EQ.0) GO TO 1000
000317      NJ=NJ+1
000318      JUN(N)=NJ
000319      JSKIP(NJ)=0
000320      GRELEV(NJ)=GRELEV(J)
000321      Z(N1)=Z(J)
000322      ZCRD(N(NJ)=ZCRD(N(J)
000323      QINST(NJ)=0.
000324      DO 960 N=1,NC
000325      IF(NJUNC(N1,2).NE.NCOND(N)) GO TO 960
000326      IF(NJUNC(N1,1).EQ.0) NJUNC(N,1)=NJ
000327      IF(NJUNC(N1,2).EQ.0) NJUNC(N,2)=NJ
000328      NCHAN(NJ,1)=N
000329      NCHAN(NJ,2)=N1
000330      NJUNC(N1,1)=J
000331      NJUNC(N1,2)=NJ
000332      DO 940 K=1,8
000333      IF(NCHAN(J,K)=N) 940,920,940
000334      920 NCHAN(J,K)=N1
000335      GO TO 980
000336      940 CONTINUE
000337      960 CONTINUE
000338      WRITE (N6,5400)
000339      5400 FORMAT ('THE FOLLOWING WEIR DOES NOT CONNECT TO ANY PIPE IN THE S
000340      YSTEM) REEXAMINE INPUT DATA CARD.1//')
000341      N=NTC+1
000342      GO TO 980
000343      1000 NJUNC(N1,1)=J
000344      DO 970 K=1,8
000345      IF (NCHAN(J,K)) 965,965,970
000346      965 NCHAN(J,K)=N1
000347      GO TO 980
000348      970 CONTINUE
000349      C***** PRINT WEIR DATA
000350      980 WRITE(N6,5500) 1,JUN(J),NCOND(N),KWEIR(I),YCREST(I),YTOP(I),
000351      1 *LEN(I),COEF(I),COEFS(I),NJ
000352      5500 FORMAT(4I7,3F10.1,2F10.3,110)
000353      NJUNC(N1,1)=J
000354      1020 CONTINUE
000355
000356

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00357 NTC=NTC+NWEIR 1305
00358 WRITE (N6,5520) NJ
00359 5520 FORMAT('INITIAL NUMBER OF NODES AFTER CONVERSION OF WEIR DATA,',I5) 1308
00360 1040 CONTINUE
00361 C
00362 C***** PUMP DATA 1309
00363 C
00364 DO 1060 I=1,20 1311
00365 NNTC=I 1312
00366 READ(N5,5540) (NJUNC(N,K),K=1,2),VWELL(I),(PRATE(I,K),K=1,3), 1313
00367 1 (VPRATE(I,K),K=1,3) 1314
00368 5540 FORMAT(2I5,7F5.0) 1315
00369 IF (NJUNC(N,I).GE.90000) GO TO 1080 1316
00370 1060 CONTINUE 1317
00371 1080 NPMPI=I 1318
00372 C***** PRINT PUMP NODES 1319
00373 IF (NPMPI) 1260,1200,1100 1320
00374 1100 WRITE(N6,5560) 1321
00375 5560 FORMAT('0PUMP DATA,') 1322
00376 DO 1120 I=1,NPMPI 1323
00377 NNTC=I 1324
00378 1120 WRITE(N6,5580) I,(NJUNC(N,K),K=1,2),VWELL(I),(PRATE(I,K),K=1,3), 1325
00379 1 (VPRATE(I,K),K=1,3) 1326
00380 5580 FORMAT(3I6,7F10.0) 1327
00381 C***** CONVERT TO INTERNAL NUMBER SYSTEM 1328
00382 DO 1240 I=1,NPMPI 1329
00383 NNTC=I 1330
00384 LPUMP(I)=N 1331
00385 NCNDIN=N 1332
00386 DO 1220 K=1,2 1333
00387 DO 1140 J=1,NJ 1334
00388 IF (NJUNC(N,K)-JUN(J)) 1140,1160,1140 1335
00389 1140 CONTINUE 1336
00390 1160 NJUNC(N,K)=J 1337
00391 DO 1180 KK=1,8 1338
00392 IF (NCHAN(J,KK)) 1200,1200,1180 1339
00393 1180 CONTINUE 1340
00394 1200 NCHAN(J,KK)=N 1341
00395 1220 CONTINUE 1342
00396 C***** SET INVERT ELEVATION,JSKIP, AND INFLOW INDEX FOR PUMP NODE 1343
00397 JP=NJUNC(N,I) 1344
00398 Y(JP)=0. 1345
00399 Y(LJP)=0. 1346
00400 Z(JP)=50.0 1347
00401 JSKIP(JP)=1 1348
00402 JFUL(I)=1 1349
00403 1240 CONTINUE 1350
00404 1260 NTC=NTC+NPMPI 1351
00405 C 1352
00406 C***** FREE OUTFLOW DATA 1353
00407 C 1354
00408 DO 1280 I=1,25 1355
00409 READ(N5,5000) JFREE(I) 1356
00410 5000 FORMAT(I5) 1357
00411 IF (JFREE(I).GE.90000) GO TO 1300 1358
00412 1280 CONTINUE 1359
00413 1300 NFREL=I-1 1360
00414 C***** PRINT FREE OUTFLOW NODES 1361
00415 IF (NFREL) 1400,1400,1320 1362
00416 1400 CONTINUE 1363
00417 1364

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000417 1320 WRITE(N6,5620) (JFREE(I),I=1,NFREE)
000418 5620 FORMAT (INFREE OUTFLOW AT JUNCTIONS.,1,4X,9I10/(30X,9I10))
000419 C***** CONVERT TO INTERNAL NUMBER SYSTEM
000420 1340 DO 1390 I=1,NFREE
000421 DO 1360 J=1,NJ
000422 IF(JFREE(I)-JUN(J)) 1360,1380,1360
000423 1360 CONTINUE
000424 1380 JFREE(I)=J
000425 N=NTC+1
000426 NJUNC(N,1)=J
000427 NJUNC(N,2)=0
000428 NCHAN(J,2)=N
000429 NCOND(N)=N
000430 JSKIP(J)=1
000431 1390 CONTINUE
000432 NTC=NTC+NFREF
000433 1400 CONTINUE
000434 C***** TIDE GATE DATA (EXCEPT WEIRS)
000435 C
000436 DO 1420 I=1,25
000437 HEAD(N5,5640) JGATE(I)
000438 5640 FORMAT(15)
000439 IF(JGATE(I).GE.90000) GO TO 1440
000440 1420 CONTINUE
000441 1440 NGATE=I-1
000442 C***** PRINT TIDE GATE NODES
000443 IF(NGATE) 1520,1520,1460
000444 1460 WRITE(N6,5660) (JGATE(I),I=1,NGATE)
000445 5660 FORMAT(10TIDE GATE (WITHOUT WEIRS) AT JUNCTIONS.,1,8I10/(40X,8I10))
000446 C***** CONVERT TO INTERNAL NUMBER SYSTEM
000447 DO 1500 I=1,NGATE
000448 DO 1480 J=1,NJ
000449 IF(JGATE(I)-JUN(J)) 1480,1500,1480
000450 1480 CONTINUE
000451 1500 JGATE(I)=J
000452 1520 CONTINUE
000453 C***** INTERNAL CONNECTIVITY INFORMATION
000454 WRITE (N6,5665)
000455 5665 FORMAT (//////, INTERNAL CONNECTIVITY INFORMATION///)
000456 WRITE (N6,5670)
000457 5670 FORMAT (' CONDUIT JUNCTION JUNCTION')
000458 N1=NC+1
000459 DO 1525 N=1,NTC
000460 J1=NJUNC(N,1)
000461 J2=NJUNC(N,2)
000462 JN=0
000463 IF(J2.GT.0) JN=JUN(J2)
000464 WRITE(N6,5675) NCOND(N),JUN(J1),JN
000465 5675 FORMAT (11I,2I13)
000466 1525 CONTINUE
000467 WRITE (N6,5365)
000468 5365 FORMAT ('0 JUNCTION GROUND INVERT DINST',15X,'CONNMIB
000469 IECTING CONDUITS',7X,'ELEV.',1,6X,'ELEV.',1,5X,'(CFS)',1)
000470 N12=NJ1+1
000471 IF(NJ2.GT.NJ) GO TO 1537
000472 DO 1535 J=NJ2,NJ
000473 MPT=0
000474 DO 1530 I=1,8
000475 K1=NCHAN(J,I)
000476

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000477 IF(K1.EQ.0) GO TO 1535
000478 IDUM(I)=NCOND(K1)
000479 IF (IDUM(I).LE.0) GO TO 1535
000480 MPTEMP=1
000481 1530 CONTINUE
000482 1535 WRITE (N6,5380) J,JUN(J),GRELEV(J),Z(J),QINST(J),IDUM(K),K=1,MP1)
000483 1537 CONTINUE
000484 C
000485 C***** TIDAL BOUNDARY DATA
000486 C
000487 READ(5,5720) NTIDE,A1,A2,A3,A4,A5,A6,A7,M
000488 5720 FORMAT(15,F10.0,F5.0)
000489 GO TO (1800,1790,1780,1760),NTIDE
000490 C
000491 C NTIDE=1 NO CONTROL WATERSURFACE AT THE OUTFALLS
000492 C NTIDE=2 OUTFALL CONTROL WATERSURFACE AT CONSTANT ELEVATION=A1
000493 C NTIDE=3 TIDE COEFFICIENTS HEAD IN
000494 C NTIDE=4 COMPUTE TIDE COEFFICIENTS
000495 C
000496 1760 READ(N5,5740) NO,NI,NCHTID
000497 5740 FORMAT (3I5)
000498 5760 READ (N5,5760) (TI(I),YY(I),I=1,NI)
000499 5760 FORMAT (8F10.0)
000500 CALL TIDCF(A0,NI,NCHTID)
000501 GO TO 1800
000502 1780 WRITE(N6,5780) A1,A2,A3,A4,A5,A6,A7,M
000503 5780 FORMAT(10TIDAL COEFFICIENTS,1,F10.4/10TIDAL PERIOD (HRS),1,F8.2)BM
000504 GO TO 1800
000505 1790 WRITE (N6,5790) A1
000506 5790 FORMAT(100OUTFLOW CONTROL WATER SURFACE ELEVATION IS',F7.2,' FEET')BM
000507 1800 CONTINUE
000508 C
000509 C***** SET PRINT & PLOT ARRAYS IN INTERNAL NUMBER SYSTEM
000510 DO 1545 K=1,NPRT
000511 DO 1540 I=1,NC
000512 IF (NCOND(I).NE.CPRT(K)) GO TO 1540
000513 CPRT(K)=I
000514 GO TO 1545
000515 1540 CONTINUE
000516 1545 CONTINUE
000517 IF(LPLT) 1640,1640,1560
000518 DO 1620 K=1,LPLT
000519 DO 1680 N=1,NC
000520 IF(NCOND(N).EQ.KPLT(K)) GO TO 1600
000521 1580 CONTINUE
000522 WRITE (N6,5680) KPLT(K)
000523 5680 FORMAT (18NO CONDUIT LOCATED FOR THIS REQUESTED PIPE PLOT',I7)
000524 GO TO 1620
000525 1600 KPLT(K)=N
000526 1620 CONTINUE
000527 DO 1660 I=1,NPRT
000528 DO 1660 J=1,NJ
000529 IF(JUN(J).EQ.JPRT(I)) JPRT(I)=J
000530 CONTINUE
000531 IF(NPLT.LE.0) GO TO 1740
000532 DO 1720 N=1,NPLT
000533 DO 1680 J=1,NJ
000534 IF (JUN(J).EQ.JPLT(N)) GO TO 1700
000535 1680 CONTINUE
000536 WRITE (N6,5780) JPLT(N)

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000597      5840 FORMAT (F8.2,I2,I10,I2,I10,I2)
000598      READ(N21) T2,(OTAPE(L,2),L=1,NJSW)
000599      TPI=I2/J5800.
000600      WRITE(N6,5840) TPI,(OTAPE(L,2),L=1,NJSW)
000601      NINREC=2
000602
000603      C***** INPUT HYDROGRAPH DATA (CARDS): TYPE L
000604      C
000605      1940 IF(NJSW) 2040,2040,1960
000606      1960 READ(N5,5860) (J5W(L),L=1,NJSW)
000607      5860 FORMAT(1615)
000608      WRITE(N6,5880) NJSW,(J5W(L),L=1,NJSW)
000609      5880 FORMAT(11INPUT HYDROGRAPHS (CARDS) AT,15,1 JUNCTIONS,/(8X,12I10)10M
000610      1)
000611      C***** CONVERT TO INTERNAL NUMBERS
000612      DO 2020 L=1,NJSW
000613      DO 1980 J=1,NJ
000614      IF(J5W(L)-JUN(J)) 1980,2000,1980
000615      1980 CONTINUE
000616      WRITE(N6,5820) J5W(L)
000617      GO TO 2020
000618      2000 J5W(L)=J
000619      2020 CONTINUE
000620      C***** READ FIRST TWO HYDROGRAPH RECORDS
000621      READ(N5,5900) TE0,(OCARD(1,1),L=1,NJSW)
000622      5900 FORMAT(6F10.0)
000623      WRITE(N6,5830)
000624      WRITE(N6,5840) TE0,(OCARD(L,1),L=1,NJSW)
000625      READ(N5,5900) TE,(OCARD(L,2),L=1,NJSW)
000626      WRITE(N6,5840) TE,(OCARD(L,2),L=1,NJSW)
000627      TE0 = TE*3600.
000628      TE=TE*3600.
000629      TIME0=TE0
000630      2040 CONTINUE
000631      C
000632      IF (NSTOP.EQ.1) STOP
000633      RETURN
000634      END

```

* ELT INFLOW,1.740718, 62223

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010001 SUBROUTINE INFLOW
010002 C
010003 C THIS SUBROUTINE SELECTS THE INPUT HYDROGRAPH
010004 C ORIGINATE FROM TAPE AND/OR CARDS
010005 C
010006 COMMON/CONTR/ N5,N6,N21,ATCYC,DELTA,DELTA2,TZER0,ALPHA(38),
010007 1 NJ,NC,NTC,ICVC,MJSM,MJSM,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,A8
010008 C
010009 COMMON/JUNC/Y(200),YT(200),ACHAN(200,8),AS(200),Z(200),GTN(200),
010010 1 GOU(200),GINST(200),GRELEV(200),JUN(200),ZCHON(200),JSKIP(200)
010011 2 ,SUMAL(200)
010012 C
010013 COMMON/GVAL/INQUAL
010014 C
010015 COMMON/HYFLOW/ LSW(200),QTAPE(200,2),JSM(200),QCHON(200),
010016 1 WATSH(200),TEO,TP,T2,TC,T20,TIMEQ,ASTEPS,NINREC
010017 C
010018 C
010019 C
010020 C
010021 DO 100 J=1,NJ
010022 100 GIN(J)=GINST(J)
010023 C
010024 C ***** TAPE VALUES FROM WATERSHED MODEL ARE INTERPOLATED
010025 IF (MJSM) 200,200,120
010026 120 IF (TIME-T2) 220,140,140
010027 C ***** NEW INPUT DATA REQUIRED
010028 140 DO 100 L=1,MJSM
010029 JIS=L
010030 SLOPE=(QTAPE(L,2)-QTAPE(L,1))/(T2-T20)
010031 Q1=QTAPE(L,1)+SLOPE*(TP-T20)
010032 Q2=QTAPE(L,2)
010033 160 GIN(J)=GIN(J)+0.5*(Q1+Q2)*(T2-TP)
010034 TP=T20
010035 DO 100 L=1,MJSM
010036 180 QTAPE(L,1)=QTAPE(L,2)
010037 IF (NINREC-NSTEPS) 200,200,220
010038 200 READ(N21) T2,(QTAPE(L,2),L=1,MJSM)
010039 TPT=T2/3600
010040 NINREC=NINREC+1
010041 WRITE(N6,5000) TPT,QTAPE(L,2),L=1,MJSM
010042 5000 FORMAT (F8.2,I2F10.2/27(8Y,12F10.2))
010043 GO TO 120
010044 C ***** NO NEW INPUT DATA REQUIRED
010045 220 DO 240 L=1,MJSM
010046 JIS=L
010047 SLOPE = 0.0
010048 IF (T2-GT,120) SLOPE=(QTAPE(L,2)-QTAPE(L,1))/(T2-T20)
010049 Q1=QTAPE(L,1)+SLOPE*(TP-T20)
010050 Q2=QTAPE(L,2)+SLOPE*(TIME-T20)
010051 240 GIN(J)=GIN(J)+0.5*(Q1+Q2)*(TIME-TP)
010052 TP=TIME
010053 C
010054 C ***** CARD INPUT: VALUES ARE INTERPOLATED
010055 280 IF (MJSM) 420,420,300
010056 300 IF (TIME-TE) 380,320,320

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STEVE,520308,1,50
C***** NEW INPUT DATA REQUIRED
320 DO 340 L=1,NJSW
  J=JS*(L)
  SLOPE=(QCARD(L,2)-QCARD(L,1))/(TE-TE0)
  Q1=QCARD(L,1)+SLOPE*(TIMEU-TE0)
  Q2=QCARD(L,2)
  340 QIN(J)=QIN(J)+0.5*(Q1+Q2)*(TE-TIME0)
  TE0=TE
  TIME0=TE0
  DO 360 L=1,NJSW
    360 QCARD(L,1)=QCARD(L,2)
    READ(5,5020) TF,(QCARD(L,2),L=1,NJSW)
    WRITE(6,5000) TF,(QCARD(L,2),L=1,NJSW)
    TF=3000.*TF
  5020 FORMAT(6F10.0)
  GO TO 380
C***** NO NEW INPUT DATA REQUIRED
380 DO 400 L=1,NJSW
  J=JS*(L)
  SLOPE=(QCARD(L,2)-QCARD(L,1))/(TE-TE0)
  Q1=QCARD(L,1)+SLOPE*(TIMEU-TE0)
  Q2=QCARD(L,1)+SLOPE*(TIME-TE0)
  400 QIN(J)=QIN(J)+0.5*(Q1+Q2)*(TIME-TIME0)
  TIME0=TIME
C
420 DO 440 J=1,NJ
  440 QIN(J)=QIN(J)/DELT
  RETURN
END

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SND,52638N,1,188

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000237 C***** (CHECK PRINTOUT REQUIREMENTS)
000238 IF (LYC-ANSTART) 640,580,580
000239 580 ANSTART=ANSTART+INTER
000240 LTIME=LTIME+1
000241 C***** STORE HGL FOR PRINTOUT
000242 DO 600 I=1,NHPT
000243 J=JHPT(I)
000244 YMAX=ZCROWN(J)-Z(I)
000245 PRV(LTIME,I)=AMIN((J),YMAX)
000246 600 PRV(LTIME,I)=Y(J)+Z(J)
000247 C***** STORE FLOW & VELOCITY FOR PRINTOUT
000248 DO 620 I=1,NHPT
000249 L=CPRT(I)
000250 NL=NJUNC(L,1)
000251 NH=NJUNC(L,2)
000252 PRV(LTIME,I)=Q(L)
000253 620 PRV(LTIME,I)=V(L)
000254 NPK=0
000255 JP=0
000256 DO 624 L=1,NJ
000257 IF (IFLG(L)) 624,624,621
000258 621 JP=JP+1
000259 NPK=1
000260 NHPT(JP)=JUNC(L)
000261 QHYD(JP)=QIR(L)
000262 QFLOW(JP)=QSUR(L)*DELTA
000263 DO 621 KK=1,N
000264 V=VCHA(L,KK)
000265 QEL(JP,KK)=Q(N)
000266 NCC(IP,KK)=NCOND(N)
000267 623 CONTINUE
000268 624 CONTINUE
000269 IF (NPK) 628,628,629
000270 629 CONTINUE
000271 TP=TIME/3600.
000272 ATTE (6,625) TP, LTIME
000273 625 FORMAT (77,1 AT TIME (HOURS) ',F6.2,1 PRINT CYCLE',15,1
000274 1,1 JUNCT SUM FLOW Q IN COND Q COND Q COND Q
000275 2COND Q COND Q COND Q COND Q COND Q',1)
000276 WRITE (6,626) (NHPT(JP),QFLOW(JP),QHYD(JP),(NCC(JP,KK),QEL(J
000277 JP,KK),KK=1,N),JJP=1,JP)
000278 626 FORMAT(15,2F10.0,3X,8(15,F6.0))
000279 628 CONTINUE
000280 DO 627 J=1,NJ
000281 627 IFLG(J)=0
000282 644 CONTINUE
000283 C
000284 C***** STORE HGL & FLOW FOR PRINTER PLOT ROUTINE
000285 IPLT(,IPLOT)=TIME/3600.
000286 IF (NPLT) 700,700,660
000287 660 DO 630 N=1,NHPT
000288 J=JHPT(N)
000289 680 IPLT(NPLOT,N)=Y(J)+Z(J)
000290 700 IF (LPLT) 760,760,720
000291 720 DO 740 N=1,LPLT
000292 L=PLT(N)
000293 740 QPLT(NPLOT,N)=Q(L)
000294 760 CONTINUE
000295 C
000296 C***** PRINT & PLOT OUTPUT

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26 AUG 74 17:16132 PAGE 38
Page 37^A follows

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SHD,526308.1,100

CALL OUTPUT
STOP
END

000207
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000209

VIII-71

AD-A042 197

KCM-WRE/YTO SEATTLE WASH
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74

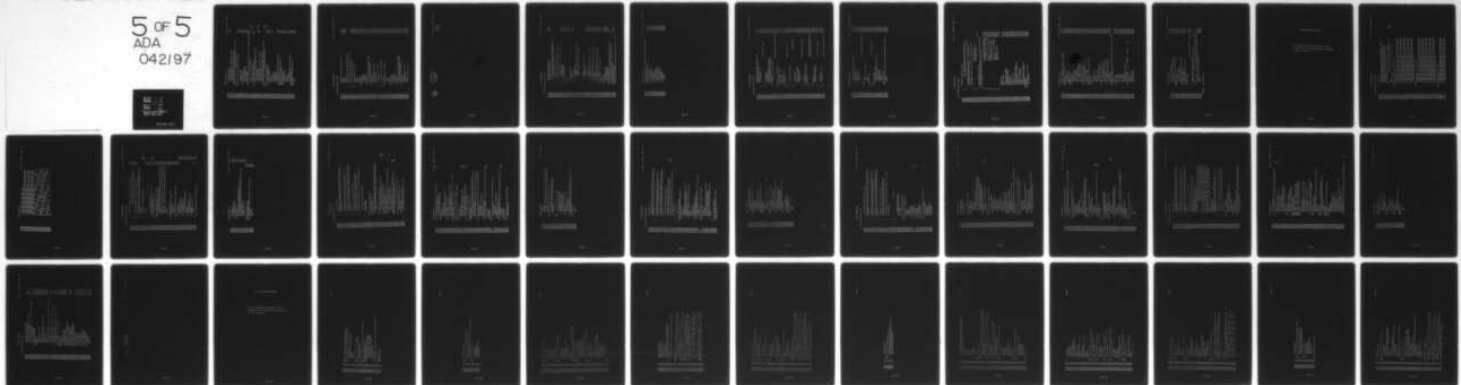
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5 OF 5
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END

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STEVE,526308,1,52

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000057      LT=MIN0(I+5,NHPT)
000058      DO 120 L=1,LTIME
000059      TIME=(TIME+FLOAT((L-1)*INTER)*DEL)/3600.
000060      LTIME=FIX (TIME)
000061      LTIME=FIX((TIME-FLOAT(LTIMEH))*60.0+0.5)
000062      120 WRITE (N6,5000) LTIME,LTIMEH,(PRTH(L,K),PRTY(L,K),K=1,LT)
000063      5000 FORMAT ('.13,.1,12.2X,6(F12.2,F8.2))
000064
000065      C***** PRINT FLOWS & VELOCITIES IN PIPES
000066      C
000067      DO 140 I=1,NOPRT
000068      L=CPRT(I)
000069      140 CPRT(I)=NCOND(L)
000070      DO 160 I=1,NOPRT,6
000071      WRITE (6,5000) ALPHA
000072      WRITE (6,5100)
000073      5100 FORMAT (125X0, '***** TIME HISTOR
000074      1 Y O F F L O W A N D V E L O C I T Y * * * * *
000075      1 * * * /,54X,10(CFS), VEL(FPS))
000076      IT=1+5
000077      IF (IT,GT,NOPRT) IT=NOPT
000078      WRITE (6,5120) (CPRT(L),L=I,IT)
000079      5120 FORMAT (1H0,1 TIME '1X,6(4X,1CONDUIT',15,4X),/
000080      1 1 HR * MIN16(5X,1 FLOW VEL
000081      1))
000082      LT=MIN0(I+5,NOPRT)
000083      DO 160 L=1,LTIME
000084      TIME=(TIME+FLOAT((L-1)*INTER)*DEL)/3600.
000085      LTIME=FIX (TIME)
000086      LTIME=FIX((TIME-FLOAT(LTIMEH))*60.0+0.5)
000087      160 WRITE (N6,5140) LTIME,LTIMEH,(PRTH(L,K),PRTY(L,K),K=1,LT)
000088      5140 FORMAT (1H .13,.1,12.2X,6(4X,F7.2,F5.1,4X))
000089
000090      C***** PRINTER PLOT PACKAGE
000091      IF (NPLT) 220,220,180
000092      IPLT=1
000093      J=JPLT(N)
000094      ZINVT=Z(J)
000095      ZCPH=ZCROW(J)
000096      Z(RND=GHELEV(J)
000097      NJUN=JUN(J)
000098      CALL CURVE(IPLT,YPLT(1,N),NPTOT,1,NJUN)
000099      240 WRITE (N6,5100) NJUN
000100      5160 FORMAT(100X,1 JUNCTION NUMBER,17)
000101      220 IF (LPLT) 340,300,240
000102      240 DO 260 L=1,5
000103      260 VERT(L)=VERTO(L)
000104      DO 280 N=1,LPLT
000105      IPLT=2
000106      L=KPLT(N)
000107      NCOND=NCOND(L)
000108      CALL CURVE(IPLT,OPLT(1,N),NPTOT,1,NKON)
000109      280 WRITE (N6,5100) NKON
000110      5180 FORMAT(100X,1 CONDUIT NUMBER,17)
000111      300 RETURN
000112      END

```

• ELT PINE,1,731128, 28621

```

010001 SUBROUTINE PINE(X1,Y1,X2,Y2,NSYM,NC1)
010002 AXA=X1
010003 AXB=X2
010004 AYA=Y1
010005 AYB=Y2
010006 IF((AXB.EQ.AXA).AND.(AYB.EQ.AYA)) RETURN
010007 N=1
010008 IF(ABS(AXB-AXA).LT.ABS(AYB-AYA)) GO TO 160
010009
010010 C SET PARAMETERS FOR X DIRECTION
010011 C
010012 IF(AXB.GT.AXA) GO TO 100
010013 AXA=X2
010014 AXB=X1
010015 AYA=Y2
010016 AYB=Y1
010017
010018 100 CONTINUE
010019 IXA=AXA+.5
010020 IXB=AXB+.5
010021 IYA=AYA+.5
010022 IYB=AYB+.5
010023
010024 120 CONTINUE
010025 IF(IXA.LT.0.OR.IXA.GT.100) GO TO 140
010026 IF(IYA.LT.0.OR.IYA.GT.50) GO TO 140
010027 CALL PLOT(IXA,IYA,NSYM,NC1)
010028
010029 140 CONTINUE
010030 IXA=IXA+1
010031 IYA=(N-(AYB-AYA))/(AXB-AXA)
010032 IYA=AYA+YA+.5
010033 N=N+1
010034 IF(IXA.LE.IXB) GO TO 120
010035 GO TO 260
010036
010037 C SET PARAMETERS FOR Y DIRECTION
010038 C
010039 160 CONTINUE
010040 IF(AYB.GT.AYA) GO TO 180
010041 AYB=Y1
010042 AYA=Y2
010043 AXA=X2
010044 AXB=X1
010045
010046 180 CONTINUE
010047 IXA=AXA+.5
010048 IYB=AYB+.5
010049 IYA=AYA+.5
010050 IYB=AYB+.5
010051
010052 200 CONTINUE
010053 IF(IXA.LT.0.OR.IXA.GT.100) GO TO 220
010054 IF(IYA.LT.0.OR.IYA.GT.50) GO TO 220
010055 CALL PLOT(IXA,IYA,NSYM,NC1)
010056
010057 220 CONTINUE
010058 IYA=IYA+1
010059 IXA=(N-(AXB-AXA))/(AYB-AYA)
010060 IXA=XA+XA+.5
010061 N=N+1
010062 IF(IYA-1YB) 200,240,260
010063
010064 1001PIN
010065 1022PIN
010066 1023PIN
010067 1024PIN
010068 1025PIN
010069
010070 1008PIN
010071 1029PIN
010072 1010PIN
010073 1011PIN
010074 1012PIN
010075 1013PIN
010076 1014PIN
010077 1015PIN
010078 1016PIN
010079 1017PIN
010080 1018PIN
010081 1019PIN
010082 1020PIN
010083 1021PIN
010084 1022PIN
010085 1023PIN
010086 1024PIN
010087 1025PIN
010088 1026PIN
010089 1027PIN
010090 1028PIN
010091 1029PIN
010092 1030PIN
010093 1031PIN
010094 1032PIN
010095 1033PIN
010096 1034PIN
010097 1035PIN
010098 1036PIN
010099 1037PIN
010100 1038PIN
010101 1039PIN
010102 1040PIN
010103 1041PIN
010104 1042PIN
010105 1043PIN
010106 1044PIN
010107 1045PIN
010108 1046PIN
010109 1047PIN
010110 1048PIN
010111 1049PIN
010112 1050PIN
010113 1051PIN
010114 1052PIN
010115 1053PIN
010116 1054PIN
010117 1055PIN

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STEVE, 526308, 1, 50

240 1A = 1X8
CG TO 200
260 RETURN
END

010057
010058
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010060

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1356PIN
1457PIN
1358PIN
1459PIN

VIII-74

STEVE,526308,1,50

130X, 'WALNUT CREEK, CALIFORNIA', 91X, 'STORM DRAINAGE MODEL', 7)

1400 FORMAT(45X,26A4)
1500 FORMAT(3X,2A4,7X,101A1)

260 DO 300 I=1,50

DO 280 J=1,10

280 A(I,J)=SYM(7)

A(1,1)=SYM(8)

300 CONTINUE

DO 320 J=1,10

320 A(51,J)=SYM(9)

DO 340 I=1,101,10

340 A(51,I)=SYM(8)

DO 360 I=1,41,10

A(1,1)=SYM(9)

360 CONTINUE

RETURN

END

0100857

0100858

0100859

0100860

0100861

0100862

0100863

0100864

0100865

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0100871

0100872

0100873

1041PPL

1042PPL

1043PPL

1044PPL

1045PPL

1046PPL

1047PPL

1048PPL

1049PPL

1050PPL

1051PPL

1052PPL

1053PPL

1054PPL

1055PPL

1056PPL

STEVE,526308,1,50

* ELT SCALE,1,731128, 26621

```

000001 SUBROUTINE SCALE (ARRAY,AXLEN,NPTS,INC)
000002 DIMENSION ARRAY(NPTS),INT(5)
000003 DATA INT /2.4,5.8,10/
000004 INCT=IABS(INC)
000005
000006
000007
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000056

      SCAL FOR MAX AND MIN

      AMAX=ARRAY(1)
      AMIN=ARRAY(1)
      DO 100 N=1,NPTS,INCT
      IF (AMAX-LT.ARRAY(N)) AMAX=ARRAY(N)
      IF (AMIN-GT.ARRAY(N)) AMIN=ARRAY(N)
      100 CONTINUE
      IF (AMAX - AMIN ) 100,100,100

      RESET MAX AND MIN FOR ZERO RANGE

      120 IF ( AMIN ) 160,320,140
      140 AMIN = 0.0
      AMAX = 2.0 * AMAX
      GO TO 160
      160 AMAX = 0.0
      AMIN = 2.0 * AMIN
      180 CONTINUE

      COMPUTE UNITS/INCH

      RATE=(AMAX-AMIN)/AXLEN

      A=ALOG10(RATE)
      N=A
      IF (A.LT.0) N=A-0.9999
      RATE=RATE/(10.**N)
      L=RATE+1.00

      FIND NEXT HIGHER INTERVAL

      200 DO 220 I=1,5
      IF (L-INT(I)) 240,240,220
      220 CONTINUE

      L IS NEXT HIGHER INTERVAL
      RANGE IS SCALED BACK TO FULL SET

      240 L=INT(I)
      RANGE=FLOAT(L)*IC.**N
      IF (INC.LT.0) GO TO 300

      SET UP POSITIVE STEPS

      K=AMIN/RANGE
      IF (AMIN.LT.0.) K=K-1

      CHECK FOR MAX VALUE IN RANGE

```

STEVE,526308,1,50

```

000057 C
000058 IF (AMAX.GT.(K+XLEN)*RANGE) GO TO 260
000059 I=NPTS+INCT+1
000060 ARRAY(I)=K*RANGE
000061 I=I+INCT
000062 ARRAY(I)=RANGE
000063 RETURN
000064
000065 C
000066 C IF OUTSIDE RANGE RESET L AND N
000067
000068 200 L=L+1
000069 IF (L.LT.11) GO TO 200
000070 L=2
000071 N=N+1
000072 280 GO TO 200
000073
000074 C
000075 C SET UP NEGATIVE STEPS
000076
000077 300 K=AMAX/RANGE
000078 IF (AMAX.GT.0.) K=K+1
000079 IF (AMIN.LT.(K+XLEN)*RANGE) GO TO 260
000080 I=INCT+NPTS+1
000081 ARRAY(I)=K*RANGE
000082 I=I+INCT
000083 ARRAY(I)=-RANGE
000084 RETURN
000085 320 *RITE(6,1000)
000086 1000 FORMAT( // 10X, 'RANGE AND SCALE ARE ZERO ON PLOT ATTEMPT' )
000087 END

```

10575CA
 10585CA
 10595CA
 10605CA
 10615CA
 10625CA
 10635CA
 10645CA
 10655CA
 10665CA
 10675CA
 10685CA
 10695CA
 10705CA
 10715CA
 10725CA
 10735CA
 10745CA
 10755CA
 10765CA
 10775CA
 10785CA
 10795CA
 10805CA
 10815CA
 10825CA
 10835CA
 10845CA
 10855CA
 10865CA

* ELY TIDCF, 1.7J1128, 28021

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000001 SUBROUTINE TIDCF(KO,NI,NCHTID)
000002 C
000003 C THIS SUBROUTINE COMPUTES SEVEN COEFFICIENTS
000004 C FOR A FOURIER EXPANSION OF THE DIURNAL TIDE STAGE
000005 C
000006 COMMON/CONTH/ N5,N6,N21,NTCYC,DELTA,DEL12,TZERO,ALPHA(3W),
000007 C 1 NJ,NC,ICYC,NJSW,NJSW,TIME2,ALPHA(3),A4,A5,A6,A7,A
000008 C
000009 COMMON/TIDE/ YY(50) , TT(50) , AA(10),SXX(10,10),SXY(10)
000010 C
000011 C TIDE COEFFICIENTS
000012 C TIDAL CURVE FIT, 7 TERM
000013 C SINUSOIDAL EQUATION
000014 C
000015 C
000016 C WRITE (N6,140) KO,NI,NCHTID
000017 C
000018 C 140 FORMAT (7H# KO IS,13,10H NUMBER OF POINTS ,14,35H MAXIMUM NUMBER
000019 C 1 OF ITERATIONS IS 50,21H TIDE CHECK SWITCH IS,12)
000020 C
000021 C IF KO EQUALS ONE, PROGRAM WILL
000022 C READ FOUR POINTS OF INFORMATION
000023 C AND EXPAND THEM FOR A FULL TIDE
000024 C
000025 C NT IS THE NUMBER OF INFORMATION
000026 C POINTS
000027 C IF NCHTID EQUALS ONE, TIDAL
000028 C INPUT-OUTPUT WILL BE PRINTED
000029 C
000030 C MAXIT IS THE MAXIMUM NUMBER OF
000031 C ITERATIONS
000032 C DELTA IS THE ACCURACY
000033 C LIMIT IN FEET
000034 C
000035 C
000036 C PERIOD = 25.
000037 C MAXIT = 50
000038 C DELTA = 0.005
000039 C NT=7
000040 C N = 2.3.14159 / PERIOD
000041 C IF(KO.EQ.0) GO TO 225
000042 C TT(50) = TT(1)+PERIOD
000043 C YY(50)=YY(1)
000044 C DO 220 I=1,4
000045 C J=I+1
000046 C IF (J.GT.4) J=50
000047 C NI=NI+1
000048 C TT(NI)=(J.*TT(I)+TT(J))/4.
000049 C YY(NI)=0.8535*YY(I)+0.1465*YY(J)
000050 C NI=NI+1
000051 C TT(NI)=(TT(I)+TT(J))/2.
000052 C YY(NI)=(YY(I)+YY(J))/2.
000053 C NI=NI+1
000054 C TT(NI)=(TT(I)+3.*TT(J))/4.
000055 C YY(NI)=0.1465*YY(I)+0.8535*YY(J)
000056 C 220 CONTINUE
000057 C 225 CONTINUE
000058 C IF (NCHTID.NE.1) GO TO 240
000059 C WRITE (N6,146)
000060 C
000061 C
000062 C
000063 C
000064 C
000065 C
000066 C
000067 C
000068 C
000069 C
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000098 C
000099 C
000100 C
000101 C
000102 C

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STEVE,526308,1.5H

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010057 146 FORMAT (29H0 NO. TIME VALUE )
010058 WRITE (N6,148) (1,TT(1), VY(1), I=1,NI)
010059 148 FORMAT (14, 2F12.3 )
010060 240 CONTINUE
010061 DO 280 J=1,NTI
010062 DO 200 K=1,NTT
010063 200 SXX(K,J) = 0.
010064 AA(J) = 0.
010065 280 SXY(J) = 0.
010066 NJ2 = NTT/2 + 1
010067 DO 300 I = 1,NI
010068 DO 320 J = 1,NTT
010069 FJ1 = FLOAT(J-1)
010070 FJ2 = FLOAT ( J-NJ2 )
010071 IF ( J.LE.NJ2 ) GO TO 300
010072 XX(I) = COS(FJ3+*TT(1))
010073 GO TO 320
010074 340 XX(J) = SIN(FJ1+*TT(1))
010075 IF ( J.EQ.1 ) XX(J) = 1.
010076 320 SXY(J) = SXY(J) + XX(J) * VY(I)
010077 DO 340 J = 1,NTT
010078 DO 340 K = 1,NTT
010079 340 SXX(K,J) = SXX(K,J) + XX(K) * XX(J)
010080 360 CONTINUE
010081 IT = 0
010082 380 IT = IT + 1
010083 DELMAX = 0.
010084 DO 420 K = 1,NTT
010085 SUM = 0.
010086 DO 400 J = 1,NTT
010087 IF (J.EQ.K) GO TO 400
010088 SUM = SUM -AA(J)+SXX(K,J)
010089 400 CONTINUE
010090 SUM = (SUM+SXY(K))/SXX(K,K)
010091 DEL = ABS(SUM-AA(K))
010092 IF (DEL.GT.DELMAX ) DELMAX = DEL
010093 420 AA(K) = SUM
010094 IF ( IT.GE.MAXIT ) GO TO 440
010095 IF ( OFLMAX.GT.DELTA ) GO TO 380
010096 GO TO 460
010097 440 WRITE(N6,150)
010098 150 FORMAT (1 ' CANNOT REACH DESIRED DELTA, INCREASE EITHER NI OR DELTA
010099 1 AND TRY AGAIN')
010100 STOP
010101 460 CONTINUE
010102 A1 = AA(1)
010103 A2 = AA(2)
010104 A3 = AA(3)
010105 A4 = AA(4)
010106 A5 = AA(5)
010107 A6 = AA(6)
010108 A7 = AA(7)
010109 IF (NCHTID.NE.1) GO TO 540
010110 WRITE (N6,152)
010111 152 FORMAT (46H0 TIME OBSERVED COMPUTED DIFF )
010112 RES = 0.
010113 DO 520 I = 1,NI
010114 SUM = 0.
010115 DO 500 J = 2,NTT
010116 FJ1 = FLOAT ( J-1 )

```

STEVE, S26338, 1, 50

```

000117 FJ3 = FLOAT ( J-NJ2 )
000118 IF ( J.LE.NJ2 ) GO TO 480
000119 SUM = SUM +A(J) *COS(FJ3*H*TT(I))
000120 GO TO 500
000121 480 SUM = SUM +AA(J) *SIN(FJ1*H*TT(I))
000122 500 CONTINUE
000123 SUM = SUM +AA(1)
000124 DIFF = SUM -YY(I)
000125 RES = RES + ABS(DIFF)
000126 520 WRITE(N6,154) TT(I),YY(I),SUM,DIFF
000127 154 FORMAT ( 4F12.4 )
000128 WRITE (N6,156) RES
000129 156 FORMAT (6H0TOTAL , 30X, F12.4 )
000130 540 CONTINUE
000131 A1 = -8.616
000132
000133
000134
000135
000136
000137
000138
000139
000140
000141
000142
END CUR, 1SD VERSION 2.14

CONSTANTS FOR INPUT WAVE FORM
TIDC177
TIDC178
TIDC179

WRITE(N6,158) A1,A2,A3,A4,A5,A6,A7
158 FORMAT(///46H COEFFICIENTS FOR TIDAL STAGE ARE
1 A1 A2 A3 A4 A5 A6
2A7 //7F10.3,F12.2///31H WHERE THE WAVEFORM IS GIVE
3N BY//92H H(J) = A1 + A2.SIN(WT) + A3.SIN(2AT) + A4.SIN(3WT) + A5.TIDC184
4COS(WT) + A5.COS(2WT) + A7.COS(3WT))
TIDC185
TIDC186
TIDC187
RETURN
END

```

TRANSPORT QUALITY BLOCK

The transport quality block program listing is presented on the following sheets identified as Pages 16 through 33.

STEVE, 526308, 1, 59

[illegible]

* ELT HYDRAD,1,740313, 29702

```

010001 SUBROUTINE HYDRAD (N,NTYPE,DEPTH,HRAD,AREA,WIDTH)
010002 C
010003 C THIS SUBROUTINE COMPUTES THE HYDRAULIC RADIUS,
010004 C SURFACE WIDTH, & CROSS-SECTION AREA FOR PIPE IN
010005 C
010006 C COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
010007 C
010008 C COMMON/COND/ NC,NTC,NCOND(200),NKCLASS(200),DEEP(200),WIDE(200),
010009 C * AFULL(200),RFULL(200),LEN(200),NJUNC(200,2),O(200,2),OAVE(200),
010010 C * V(200)
010011 C
010012 C COMMON/TRAP/ STHETA(200),SPHI(200)
010013 C
010014 C REAL LEN
010015 C
010016 C EXECUTION
010017 C
010018 C IF(DEPTH) 200,100,100
010019 C 100 GO TO (120,180,120,120,120,190), NTYPE
010020 C 120 FDEPTH=DEPTH/DEEP(N)
010021 C IF(FDEPTH-1.) 140,160,160
010022 C
010023 C ***** INTERPOLATE TABLE OF PROPERTIES
010024 C 140 I=1,IFIX(FDEPTH/0.04)
010025 C DELTA=(FDEPTH-0.04*FLOAT(I-1))/0.04
010026 C WIDTH = WIDE(N)*(TWNORM(I,NTYPE)*(TWNORM(I+1,NTYPE)-TWNORM(I,NTYPE)
010027 C 1))*DELTA)
010028 C AREA = AFULL(N)*(ANORM(I,NTYPE) + (ANORM(I+1,NTYPE)-ANORM(I,NTYPE)
010029 C 1))*DELTA)
010030 C HRAD = RFULL(N)*(HRNORM(I,NTYPE)+(HRNORM(I+1,NTYPE)-HRNORM(I,NTYPE)
010031 C 1))*DELTA)
010032 C RETURN
010033 C
010034 C ***** FULL PIPE
010035 C 160 WIDTH=WIDE(N)*TWNORM(26,NTYPE)
010036 C AREA=AFULL(N)
010037 C HRAD=RFULL(N)
010038 C RETURN
010039 C
010040 C ***** RECTANGULAR SECTION (SPECIAL CASE)
010041 C 180 WIDTH=WIDE(N)
010042 C DEPTH=DEPTH
010043 C FDEP=DEPTH-DEEP(N)
010044 C IF (FDEP) 186,186,184
010045 C 184 DEPTH=DEEP(N)
010046 C AREA=WIDE(N)*DEPTR
010047 C HRAD=AREA/(2.*(WIDE(N)+DEPTR))
010048 C GO TO 188
010049 C 186 CONTINUE
010050 C AREA=WIDE(N)*DEPTR
010051 C HRAD=AREA/(WIDE(N)+2.*DEPTR)
010052 C 188 CONTINUE
010053 C HRAD=MAX1(HRAD,0.01)
010054 C RETURN
010055 C
010056 C ***** TRAPEZOIDAL SECTION (SPECIAL CASE)

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• ELT INDATA,1,740727, 50226

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010001 SUBROUTINE INDATA
010002 C
010003 COMMON/CONTROL/ TITLE(40), ALPHA(30), BETA(30), NOCYC, NQUAL, DELT,
010004 • TZERO, NPRNT, NSTART, INTER, N21, N22, IQCYC, TIME, TE, TEO, TIMED, T2, T23,
010005 • TP, NINREC
010006 C
010007 COMMON/JUNCT/ NJ, JUNC(200), NCHAN(200,8), MASSIN(200,6), C(200,6),
010008 • V(200,2), YAVE(200), VOL(200), VOLQ(200), JSKIP(100)
010009 C
010010 COMMON/COND/ NC, NTC, NCOND(200), NKLASS(200), DEEP(200), WIDE(200),
010011 • AFULL(200), RFULL(200), LEN(200), NJUNC(200,2), Q(200,2), GAVE(200),
010012 • V(200)
010013 C
010014 COMMON/PUHP/ NPUMP, LPUMP(20), VPUMP(20)
010015 C
010016 COMMON/OUT/ JOPRI(30), CPRI(30,6,100), OPRI(30,100),
010017 I CONST(5,24), LTIME, NPLTL, NPLTH, ICOOL(25), ICODE(25)
010018 C
010019 COMMON/RUNOFF/ MJSW, NSTEPS, MATSH(200), ISW(200), WDMOT(200,6,2)
010020 C
010021 COMMON/TRAP/ STHETA(200), SPHI(200)
010022 C
010023 REAL MASSIN, LEN
010024 INTEGER MATSH
010025 C
010026 C***** HEADING (TITLE) CARDS
010027 READ (5,5000) BETA
010028 5000 FORMAT (15A4)
010029 •RITE (6,5020) BETA
010030 5020 FORMAT (1H1,15A4,20X, WATER RESOURCES ENGINEERS, INC.,1/1X,15A4,
010031 1 20X, WALNUT CREEK, CALIFORNIA/ 81X, STORM DRAINAGE QUALITY MODEL
010032 2 1//)
010033 C
010034 C***** GENERAL CONTROL PARAMETERS
010035 READ (5,5040) NOCYC, DELT, NHR, WIN, NPRNT, NSTART,
010036 1 INTER, N21, NAMEF, N22, NAMEF, NPLOT
010037 5040 FORMAT (15,F5.0,13,I2,4I5,2(4X,A6,15))
010038 •RITE (6,5060) NOCYC
010039 5060 FORMAT (10INTEGRATION CYCLES',15)
010040 •RITE (6,5070) DELT
010041 5070 FORMAT (10LENGTH OF INTEGRATION STEP ISI,F4.0,1 SECONDS',
010042 1 10X, NSTART, INTER
010043 TZERO • FLOAT(NHR)*FLOAT(WIN)/60.
010044 •RITE(6,5075) TZERO
010045 5075 FORMAT (10INITIAL TIME ISI,F5.2,1 HOURS',1//)
010046 5080 FORMAT (10PRINTING STARTS IN CYCLE',15,1 AND PRINTS',
010047 1 1 AT INTERVALS OF',14,1 CYCLES')
010048 C
010049 C***** JUNCTION NUMBERS FOR DETAILED PRINTOUT
010050 IF (NPRNT.EQ.0) GO TO 100
010051 HEAD(5,5120) (JOPRI(1), 1=1, NPRNT)
010052 5120 FORMAT (8116)
010053 HEAD(5,5240) (ICOOL(1), 1=1,25)
010054 •RITE (6,5140) NPRNT, (JOPRI(1), 1=1, NPRNT)
010055
010056

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•NEW
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STEVE,526300,1,50

5140 FORMAT (10POLLUTOGRAPHS WILL BE PRINTED AT',I4,

1 ' JUNCTIONS',/(8X,12I110))

WRITE(6,5300) (ICODL(I),I=1,25)

5300 FORMAT(10LIST CODES ARE',/25I2)

100 CONTINUE

NPLTM=NPRINT+1

READ(5,5120) (JOPRT(I),I=NPLTM,NPLTM)

READ(5,5240) (ICODE(I),I=1,25)

5240 FORMAT(25I1)

IF(NPLOT.EQ.0) GO TO 120

WRITE(6,5260) NPLOT, (JOPRT(I),I=NPLTM,NPLTM)

WRITE(6,5280) (ICODE(I),I=1,25)

5280 FORMAT(10POLLUTOGRAPHS WILL BE PLOTTED AT',I4,' JUNCTIONS',

1/(8X,12I110))

5280 FORMAT(10 PLOT CODES ARE',/25I2)

C

C***** READ WATERSHED RUNOFF CONTROL PARAMETERS

C

120 REMIND N21

READ(N21) TITLE

READ(N21) NSTEPS,MJSM,NQUAL,D1,D2,D3

READ(N21) (ISW(L),L=1,MJSM)

WRITE (6,5160) MJSM, (ISW(L), L=1, MJSM)

5160 FORMAT (10INPUT POLLUTOGRAPHS (TAPE) AT',I4,

1 ' JUNCTIONS',/(8X,12I110))

C

C***** HEAD DRAINAGE SYSTEM DATA

180 REMIND N22

200 READ (N22) NTCYC,NJ,NC,NTC, (JUN(J), (NCHAN(J,K),K=1,8),

1J=1,NJ), (NCOND(N),NKLASS(N),DEEP(N),WIDE(N),AFULL(N),RFULL(N),

1 STHEA(N),SPHI(N),

2LEN(N), (NJUNC(N,K),K=1,2),N=1,NTC),NPUMP, (LPUMP(I),I=1,NPUMP)

C

C***** CONVERT WATERSHED INPUT NODES TO INTERNAL NUMBERING SYSTEM

DO 200 L=1,MJSM

DO 240 J=1,NJ

IF (ISW(L)-JUN(J)) 240,260,240

240 CONTINUE

5180 WRITE (6,5180) ISW(L)

1)

5180 FORMAT(10POLLUTOGRAPH AT JUNCTION',I7,1000S NOT MATCH SYSTEM DATA',I8M

18M

GO TO 280

260 ISW(L)=J

280 CONTINUE

C

C***** CONVERT PRINT ARRAY TO INTERNAL NUMBERING SYSTEM

DO 340 L=1,NPLTM

DO 360 J=1,NJ

IF (JOPRT(L)-JUN(J)) 300,320,300

300 CONTINUE

WRITE(6,5200) JOPRT(L)

5200 FORMAT('NODE',I7,1 REQUESTED FOR PRINTOUT DOES NOT EXIST IN',

1 ' SYSTEM')

GO TO 340

320 JOPRT(L)=J

340 CONTINUE

C

C***** READ FIRST TWO POLLUTOGRAPH RECORDS

1ZERO =ZERO+3600.

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STEVE,526308,1,50

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000117 TP=ZERO
000118 TEO=ZERO
000119 READ(N21) T20,(TD,L=1,MJSM),((MD=DT(L,I,1),I=1,6),L=1,MJSM)
000120 READ(N21) T2,(TD,L=1,MJSM),((MD=DT(L,I,2),I=1,6),L=1,MJSM)
000121 NINREC=2
000122 C***** READ FIRST TWO SETS OF FLOW DATA
000123 C
000124 READ (N22) TEO,(QCN,1),N=1,NTC),(Y(J,1),J=1,NJ)
000125 READ (N22) TE,(QCN,2),N=1,NTC),(Y(J,2),J=1,NJ)
000126 TIMEO=TEO
000127 C
000128 C*** CHECK FOR PROPER RUN LENGTH
000129 C
000130 TMAX=T20*(NSTEPS-1)*(T2-T20)
000131 TMAXO=TEO*(NTCYC-1)*(TE-TEO)
000132 TMAX=ZERO+(NGCYC)*DELT
000133 TTHAX=AMINI(TMAX,TMAXD)
000134 IF (TTHAX-TMAX) 300,300,300
000135 300 CONTINUE
000136 TTEMP=(TTHAX-TZERO-1.)/DELT
000137 NGCYC=IFIX(TTEMP)
000138 WRITE (6,5220) NGCYC
000139 5220 FORMAT (10QUALITY SIMULATION PERIOD EXCEEDS RECORD LENGTH OF INPUT )
000140 1 DATA, NUMBER OF QUALITY CYCLES REDUCED TO,17,77)
000141 380 CONTINUE
000142 C
000143 RETURN
000144 END

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STEVE,526308,1,50

• ELT INPUT,1,740328, 34863

```

010001 SUBROUTINE INPUT
010002 C
010003 COMMON/CNTRL/ TITLE(40),ALPHA(30),BETA(30),NQCVC,NQUAL,DELT,
010004 * TZERO,NPRINT,NSTART,INTER,N21,N22,IOCYC,TIME,TE,TEO,TIMEO,T2,T20,
010005 * TP,NINREC
010006 C
010007 COMMON/JUNCT/ NJ,JUNC(200),NCHAN(200,8),MASSIN(200,6),C(200,6),
010008 * Y(200,2),YAVE(200),VOL(200),VOL0(200),JSKIP(100)
010009 C
010010 COMMON/COND/ NC,NTC,NCOND(200),NKCLASS(200),DEEP(200),WIDE(200),
010011 * AFULL(200),RFULL(200),LEN(200),NJUNC(200,2),Q(200,2),QAVE(200),
010012 * V(200)
010013 C
010014 COMMON/PUMP/ NPUMP,LPUMP(20),VPUMP(20)
010015 C
010016 COMMON/OUT/ JOPRT(30),CPRNT(30,6,100),QPRNT(J0,100),
010017 I CONST(5,24),LTIME,NPLTL,NPLTH,ICODL(25),ICODE(25)
010018 C
010019 COMMON/RUNOFF/ MJSW,NSTEPS,WATSH(200),ISW(200),WDMOT(200,6,2)
010020 DIMENSION SLOPE(0)
010021 C
010022 REAL MASSIN,LEN
010023 C
010024 C
010025 295 IF (TIME-T2)300,300,300
010026 C***** NEW INPUT POLLUTOGRAPHS REQUIRED
010027 300 DO 320 L=1,MJSW
010028 J=ISW(L)
010029 DO 320 I=1,6
010030 SLOPE(I)=(WDMOT(L,I,2)-WDMOT(L,I,1))/(T2-T20)
010031 W1=WDMOT(L,I,1)+SLOPE(I)*(TP-T20)
010032 W2=WDMOT(L,I,2)
010033 320 MASSIN(J,I)=MASSIN(J,I)+0.5*(W1+W2)*(T2-TP)
010034 T20=T2
010035 TP=I23
010036 DO 340 L=1,MJSW
010037 DO 340 I=1,6
010038 WDMOT(L,I,1)=WDMOT(L,I,2)
010039 IF (NINREC-NSTEPS) 360, 360, 300
010040 360 READ(N21) T2,(TD,L=1,MJSW),((WDMOT(L,I,2),I=1,6),L=1,MJSW)
010041 NINREC=NINREC+1
010042 GO TO 295
010043 C***** NO NEW INPUT POLLUTOGRAPHS REQUIRED
010044 380 DO 400 L=1,MJSW
010045 J=ISW(L)
010046 DO 400 I=1,6
010047 SLOPE(I)=(WDMOT(L,I,2)-WDMOT(L,I,1))/(T2-T20)
010048 W1=WDMOT(L,I,1)+SLOPE(I)*(TP-T20)
010049 W2=WDMOT(L,I,1)+SLOPE(I)*(TIME-T20)
010050 400 MASSIN(J,I)=MASSIN(J,I)+0.5*(W1+W2)*(TIME-TP)
010051 TP=TIME
010052 C
010053 C
010054 420 IF (TIME-TE) 520,440,440
010055 C***** NEW INPUT HYDRAULIC DATA REQUIRED
010056 440 DO 460 N=1,NTC

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*NEW
*NEW
***2

STEVES06308,1,54

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      SLOPE0=(Q(N,2)-Q(N,1))/(TE-TF0)
      Q1=Q(N,1)+SLOPE0*(TIME0-TE0)
      Q2=Q(N,2)
460  GAVE(N)=GAVE(N)+0.5*(Q1+Q2)*(TE-TF0)
      DO 470 N=1,NTC
470  Q(N,1)=Q(N,2)
      DO 480 J=1,NJ
      SLOPEY=(Y(J,2)-Y(J,1))/(TE-TF0)
      Y1=Y(J,1)+SLOPEY*(TIME0-TE0)
      Y2=Y(J,2)
480  YAVE(J)=YAVE(J)+0.5*(Y1+Y2)*(TE-TF0)
      DO 500 J=1,NJ
500  Y(J,1)=Y(J,2)
      TE0=TE
      TIME0=TIME
      HEAD (N22) TE, (Q(N,2),N=1,NTC), (Y(J,2),J=1,NJ)
      GO TO 420
C***** NO NEW INPUT HYDRAULIC DATA REQ. IN CD
520  DO 540 N=1,NTC
      SLOPE0=(Q(N,2)-Q(N,1))/(TE-TF0)
      Q1=Q(N,1)+SLOPE0*(TIME0-TE0)
      Q2=Q(N,1)+SLOPE0*(TIME-TF0)
540  GAVE(N)=GAVE(N)+0.5*(Q1+Q2)*(TIME-TF0)
      DO 560 J=1,NJ
      SLOPEY=(Y(J,2)-Y(J,1))/(TE-TF0)
      Y1=Y(J,1)+SLOPEY*(TIME0-TE0)
      Y2=Y(J,1)+SLOPEY*(TIME-TF0)
560  YAVE(J)=YAVE(J)+0.5*(Y1+Y2)*(TIME-TF0)
      TIME0=TIME
C
      DO 580 N=1,NTC
580  GAVE(N)=GAVE(N)/DELT
      DO 600 J=1,NJ
600  YAVE(J)=YAVE(J)/DELT
C
      RETURN
      END

```

• ELT MAIN,1,740328, 68664

```

010001 C MAIN PROGRAM OF TRANSPORT QUALITY BLOCK
010002 COMMON/CONTROL/ TITLE(40),ALPHA(30),BETA(30),NGCYC,NGUAL,DEL
010003 * TZERO,NPRINT,NSTART,INTER,N21,N22,ICQYC,TIME,TE,TEO,TIMEO,T2,T20,
010004 * TP,NINREC
010005
010006 C
010007 COMMON/JUNCT/ NJ,JUN(200),NCHAN(200,8),MASSIN(200,6),C(200,6),
010008 * Y(200,2),YAVE(200),VOL(200),VOLO(200),JSKIP(100)
010009
010010 C
010011 COMMON/COND/ NC,NTC,NCOND(200),NKLASS(200),DEEP(200),WIDE(200),
010012 * AFULL(200),RFULL(200),LEN(200),NJUNC(200,2),Q(200,2),QAVE(200),
010013 * V(200)
010014
010015 C COMMON/PUMP/ NPUMP,L,PUMP(20),VPUMP(20)
010016
010017 C COMMON/OUT/ JOPRT(30),CPRT(30,6,100),QPHNT(30,100),
010018 I CONST(5,24),LTIME,NPLTL,NPLTM,ICODL(25),ICODE(25)
010019
010020 C COMMON/RUNOFF/ HJSM,NSTEPS,WATSH(200),ISM(200),MDMOT(200,6,2)
010021
010022 C REAL MASSIN,LEN
010023
010024 C
010025 C
010026 C
010027 C
010028 C
010029 C
010030 C
010031 C
010032 C
010033 C
010034 C
010035 C
010036 C
010037 C
010038 C
010039 C
010040 C
010041 C
010042 C
010043 C
010044 C
010045 C
010046 C
010047 C
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010052 C
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010055 C
010056 C

      CALL EQUINIT(15,'GUTUAL',0,-1)
      CALL EQUINIT(12,'SEHMYD',0,-1)
      CALL INDATA

C***** EXECUTE TRANSPORT PROGRAM
C***** SYSTEM INITIALIZATION
      ICQYC=0
      NPTOT=0
      LTIME=0
      TIME=ZERO
      DO 270 I=1,6
        DO 270 C(NJ+1,I)=0
      270 C(NJ+1,I)=0
      DO 285 J=1,NJ
        DO 280 I=1,6
          DO 280 C(J,I)=0
          JSKIP(J)=0
      285 VOLO(J)=0.0
      DO 220 I=1,NPUMP
        DO 220 VPUMP(I)=0.0

C***** MAJOR PROGRAM LOOP THROUGH TIME
      DO 1100 MCY=1,NGCYC
        TIME=TIME+DEL
        ICQYC=ICQYC+1
        DO 290 I=1,6
          MASSIN(NJ+1,I)=0.
          DO 290 J=1,NJ
            YAVE(J)=0.0
  
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STEVE,526338,1,50

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290 MASSIN (J,I)=0.0
DO 300 N=1,NTC
300 QAVE(N)=0.0
C
C CALL INPUT
C
C***** COMPUTE NODAL VOLUMES
DO 620 J=1,NJ
620 VOL(J)=0.0
J1=NJUNC(N,1)
J2=NJUNC(N,2)
Y1D=0.5*(YAVE(J1)+YAVE(J2))
CALL HYDRAD(N,KLASS(N),YAVE(J1),H1D,A1,W1DTH)
CALL HYDRAD(N,KLASS(N),YAVE(J2),H2D,A2,W2DTH)
CALL HYDRAD(N,KLASS(N),Y1D,H1D,A1D,W1DTH)
VOL(J1)=VOL(J1)+0.25*(A1+A1D)*LEN(N)
VOL(J2)=VOL(J2)+0.25*(A2+A1D)*LEN(N)
C***** COMPUTE CONDUIT VELOCITY
V(N)=0.
IF (AMID.GT.0.) V(N)=QAVE(N)/AMID
640 CONTINUE
C
C***** QUALITY CHANGE AT PUMP NODES
C
IF (NPUMP) 840,840,660
DO 820 I=1,NPUMP
LINK=LPUMP(I)
JPUMP=NJUNC(LINK,1)
JSKIP(JPUMP)=1
VPUMP0=VPUMP(I)
DO 780 K=1,8
N=CHAN(JPUMP,K)
IF (N) 800,800,680
680 J1=NJUNC(N,1)
J2=NJUNC(N,2)
IF (J2-JPUMP) 700,720,700
700 QAVE(N)=QAVE(N)
720 IF (QAVE(N)) 740,760,760
740 J1=JPUMP
760 VPUMP(I)=VPUMP(I)+QAVE(N)*DELT
DO 780 II=1,6
780 MASSIN(JPUMP,II)=QAVE(N)*C(J1,II)*DELT
800 DO 820 II=1,6
820 C(JPUMP,II)=(MASSIN(JPUMP,II)+VPUMP0)/VPUMP(I)
840 CONTINUE
C
C***** COMPUTE QUALITY CHANGES AT REMAINING NODES
C
C***** ADVECTIVE TRANSPORT THROUGH CONDUITS
DO 900 N=1,NC
J1=NJUNC(N,1)
J2=NJUNC(N,2)
IF (ABS(V(N)*DELT)-LEN(N)) 860,860,850
850 V(N)=SIGN(LEN(N)/DELT,V(N))
860 DO 900 I=1,6
GRAD=(C(J2,I)-C(J1,I))/LEN(N)
IF (V(N)*GRAD) 870,870,880
870 RATE12=((C(J1,I)+C(J2,I)-GRAD*V(N)*DELT)/2.)*QAVE(N)
MASSIN(J1,I)=MASSIN(J1,I)-RATE12*DELT

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Page 29 follows

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000117 MASSIN(J2,I)=MASSIN(J2,I)+RATEI2*DELT
000118 GO TO 908
000119 880 MASSIN(J1,I)=MASSIN(J1,I)+GAVE(N)*AMIN1(C(J1,I),C(J2,I))*DELT
000120 MASSIN(J2,I)=MASSIN(J2,I)+GAVE(N)*AMIN1(C(J1,I),C(J2,I))*DELT
000121 900 CONTINUE
000122 C
000123 C***** MASS TRANSFER FROM OTHER SYSTEM LINKS
000124 IF(NTC-NC) 960,960,920
000125 920 N1=NC+1
000126 DO 940 N=N1,NTC
000127 J1=NJUNC(N,1)
000128 J2=NJUNC(N,2)
000129 IF (J2-EQ,0) J2=NJ+1
000130 JFROM=J1
000131 IF(GAVE(N) .LT. 0.0) JFROM=J2
000132 DO 940 I=1,6
000133 MASSIN(J1,I)=MASSIN(J1,I)+GAVE(N)*C(JFROM,I)*DELT
000134 940 MASSIN(J2,I)=MASSIN(J2,I)+GAVE(N)*C(JFROM,I)*DELT
000135 960 CONTINUE
000136 C
000137 C***** UPDATE JUNCTION CONCENTRATIONS
000138 DO 1000 J=1,NJ
000139 IF(CJSKIP(J)) 980,980,1000
000140 980 DO 990 I=1,6
000141 COLD=C(J,I)
000142 C(J,I)=0.
000143 IF(VOL(J).GT.0.) C(J,I)=(MASSIN(J,I)+COLD*VOLO(J))/VOL(J)
000144 990 CONTINUE
000145 VOL(J)=VOL(J)
000146 1000 CONTINUE
000147 C
000148 C***** CHECK PRINTOUT REQUIREMENTS
000149 IF(IDCYC-NSTART) 1100,1020,1020
000150 1020 NSTART=NSTART+INTER
000151 LTIME=LTIME+1
000152 C***** STORE VALUES FOR PRINTOUT
000153 DO 1080 L=1,NPLTH
000154 J=JPRINT(L)
000155 DO 1080 I=1,6
000156 CPRT(L,I,LTIME)=C(J,I)+454000./28.32
000157 1080 SUMQ=0.0
000158 C***** COMPUTE DISCHARGE THROUGH JUNCTION
000159 DO 1060 K=1,8
000160 N=NCAN(J,K)
000161 IF(NJUNC(N,1) .EQ. J .AND. GAVE(N) .GT. 0.0) SUMQ=SUMQ+GAVE(N)
000162 IF(NJUNC(N,2) .EQ. J .AND. GAVE(N) .LT. 0.0) SUMQ=SUMQ+
000163 1 ABS(GAVE(N))
000164 1060 CONTINUE
000165 CPRT(L,LTIME)=SUMQ
000166 1080 CONTINUE
000167 1100 CONTINUE
000168 C
000169 C***** END OF MAIN EXECUTION LOOP
000170 CALL OUTPUT
000171 STOP
000172 END
000173
000174
000175

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* ELT OUTPUT,1,740727, 50226

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000001 SUBROUTINE OUTPUT
000002 C
000003 COMMON/CNTRL/ TITLE(40),ALPHA(30),BETA(30),NGCYC,NQUAL,DELT,
000004 * TZERO,NPRT,NSTART,INTER,N21,N22,IGCYC,TIME,IE,TEO,TIMEO,I2,I20,
000005 * TP,NINREC
000006 C
000007 COMMON/JUNCT/ NJ,JUN(200),NCHAN(200,8),MASSIN(200,6),C(200,6),
000008 * Y(200,2),YAVE(200),VOL(200),VOLUME(200),JSKIP(100)
000009 C
000010 COMMON/COND/ NC,NTC,NCOND(200),NKLAS(200),DEEPT(200),WIDE(200),
000011 * AFULL(200),RFULL(200),LEN(200),NJUNC(200,2),Q(200,2),QAVE(200),
000012 * V(200)
000013 C
000014 COMMON/PUMP/ NPUMP,LPUHP(20),VPUMP(20)
000015 C
000016 COMMON/OUT/ JOPRT(30),OPRNT(30,6,100),OPRNT(30,100),
000017 * CONST(5,24),LTIME,NPLT,NPLTM,ICODL(25),ICODE(25)
000018 DIMENSION EPRNT(20)
000019 DIMENSION CBFACT(24),QFACT(5,24),CONOUT(20)
000020 DATA QFACT/ 100.,200.,240.,170.,153.,340.,250.,445.,249.,323.,
000021 480.,470.,315.,575.,525.,35.,7.53,1.35,9.14,0.11,0.,
000022 330.,427.,300.,240.,222.,26.,3.29,8.22,2.37,9.54,7.,
000023 317.48,4.49,8.55,7.92,2.45,1.78,6.30,2.35,4.20,0.,
000024 37.1E+5,2.9E+6,2.9E+4,6.2E+4,8.2E+4,1.9E+5,820.,7700.,2.E+4,
000025 0.66,2.89,0.93,0.61,0.37,5.00,0.61,4.45,2.82,4.13,
000026 5.2,51.,4.51,2.27,1.70,7.29, 1.06, 1.08, 0.65, 0.09, 1.19,
000027 6.0,25.,0.47,0.19,0.18,0.36, .0053, .0030, .0012, .0009, .0019,
000028 7.0,29.,0.17,0.21,0.19,0.70, 0.40, 0.33, 0.70, 0.98, 0.26,
000029 8.1,21.,1.57,1.07,0.51,0.60, .056, .052, .069, .032, .061,
000030 9.0,25.,.022, .015, .015, .030, .178, .139, .117, .171, .000,
000031 110.0,0./
000032 DATA CBFACT/24.0,0./
000033 DATA AST/1.,1./
000034 DATA EMIS1,EMIS2,FL,CN,RT,CF,XMP,XMPS,XMGL,XMGS/
000035 11EMIS1,15ION1,1FLOW1,1CONC1,1RATE1,1 CFSI,1 MPNI,1MP/SI,1MG/L1,
000036 2 1L8/91/
000037 C
000038 COMMON/RUNOFF/ MJSM,NSTEPS,WATSH(200),ISA(200),*CMOT(200,6,2)
000039 C
000040 COMMON /LAB/ TITL(10),XLAB(11),VLAB(6),HORIZ(20),VERT(7,6),IT
000041 C
000042 REAL MASSIN,LEN
000043 C
000044 C***** PROCESS OUTPUT
000045 NSTART=NSTART-LTIME*INTER
000046 TIME0=(TZERO*FLOAT(NSTART)*DELT)/3600.
000047 IF(NPRT.EQ.0) GO TO 1400
000048 DO 1200 L=1,NPRT
000049 J=JOPRT(L)
000050 DO 1230 I=1,NQUAL
000051 IF(ICODL(I+1).EQ.0) GO TO 1230
000052 FORMAT(1H1,15A4,20X,1*WATER RESOURCES ENGINEERS, INC./1X,15A4,20X,
000053 1*WALNUT CREEK, CALIFORNIA/ 81X,15FORM DRAINAGE QUALITY MODEL1)
000054 DO 1220 LL=1,NPRT,5
000055

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STEVE, 526308, 1, 58

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000357 WRITE(6,6800) BETA
000358 WRITE(6,6820) (AST,KC=1,39),(CONST(KC,I),KC=1,5),(AST,KC=1,13)
000359 FORMAT(1H8,13A4,' TIME HISTORY OF ',13A4//1X,31A4)
000360 LT=LL+4
000361 IF(LT.GT.NPRNT) LT=NPRNT
000362 WRITE(6,6840) (JPRNT(L),L=LL,LT)
000363 IF(I.EQ.9) GO TO 1398
000364 IF(I.EQ.18) GO TO 1398
000365 WRITE(6,6845) (EMIS1,EMIS2,L=LL,LT)
000366 WRITE(6,6850) (FL,CN,RT,L=LL,LT)
000367 WRITE(6,6851) (CF,XMCL,XMGS,L=LL,LT)
000368 GO TO 1358
000369
000370 CONTINUE
000371 WRITE(6,6846) EMIS1,EMIS2
000372 WRITE(6,6853) (FL,CN,RT,L=LL,LT)
000373 WRITE(6,6852) (CF,XMP,XMPS,L=LL,LT)
000374 FORMAT(1H8,13X,5('JUNCTION:',I6,9X))
000375 FORMAT(11X,5(15X,2A4))
000376 FORMAT(8X,5(15X,2A4))
000377 FORMAT(1 TIME 1,5(5X,A4,3X,A4,3X,A4))
000378 FORMAT(1 HR-MIN 1,5(5X,A4,3X,A4,3X,A4))
000379 FORMAT(1 HR-MIN 1,5(2X,A4,3X,A4,3X,A4,3X))
000380 FORMAT(1 TIME 1,5(2X,A4,3X,A4,3X,A4,3X))
000381
000382 DO 1220 IT=1,LTIME
000383 TIME=TIME+(FLOAT(IT-1)*INTER)*DELT/3600.
000384 LTIME=ITX(TIME)
000385 LTIME=IFIX(LTIME-FLOAT(LTIMEH))*63+.5
000386 DO 1210 L=LL,LT
000387 CONOUT(L)=CPRNT(L,6,IT)*CBFACT(I)
000388 DO 1205 II=1,5
000389 CONOUT(L)=CPRNT(L,II,IT)*QFACT(II,I)*CONOUT(L)
000390 EPRNT(L)=EPRNT(L,IT)*CONOUT(L)*6.2435E-5
000391 CONTINUE
000392 IF(I.LT.9) GO TO 1215
000393 IF(I.GT.18) GO TO 1215
000394 WRITE(6,6865) LTIME,LTIMEH,(QPRNT(L,IT),CONOUT(L),EPRNT(L),
000395 2 L=LL,LT)
000396 GO TO 1220
000397
000398 1215 CONTINUE
000399 FORMAT(1H ,13,'1,12,2X,5(0PF7.2,1P2E8,2))
000400 WRITE(6,6860) LTIME,LTIMEH,(QPRNT(L,IT),CONOUT(L),
000401 1 EPRNT(L), L=LL,LT)
000402 CONTINUE
000403 1220 CONTINUE
000404 1230 CONTINUE
000405 FORMAT(1H ,13,'1,12,2X,5(P9.2,F7.2,F7,3))
000406 NCV=1
000407 CONTINUE
000408 NPT(1)=LTIME
000409 NQUALP=NQUAL+1
000410 IF(NPLTL.GT.NPLTM) RETURN
000411 DO 2000 L=NPLTL,NPLTM
000412 DO 1950 I=1,NQUALP
000413 IF(ICODE(I).EQ.0) GO TO 1950
000414 DO 1900 IT=1,LTIME
000415 X(IT,I)=TIMES+(FLOAT(IT-1)*INTER)*DELT/3600.
000416 IF(I.EQ.1) GO TO 1870
000417 Z(IT,I)=CPRNT(L,6,IT)*CBFACT(I-1)
000418 DO 1850 II=1,5
000419 Z(IT,I)=Z(IT,I)+CPRNT(L,II,IT)*QFACT(II,I-1)*QPRNT(L,IT)*6.2435E-5
000420
000421 1850 Z(IT,I)=Z(IT,I)+CPRNT(L,II,IT)*QFACT(II,I-1)*QPRNT(L,IT)*6.2435E-5
000422
000423 *NEW

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STEVE,526338,1,58

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GO TO 1948
1878 Z(I,1)=OPRT(L,1)
1948 CONTINUE
IF(I.EQ.1) GO TO 1938
IT=2
IF(I.EQ.10.OR.I.EQ.11) IT=3
DO 1928 N=3,7
1928 TIL(N)=CONST(N-2,1-1)
GO TO 1948
1938 CONTINUE
IT=1
TIL(3)=VERT(1,1)
TIL(4)=VERT(2,1)
DO 1935 N=5,7
1935 TIL(N)=VERT(5,1)
1948 CONTINUE
JT=JOPRT(L)
JOPRT(L)=JUN(JT)
CALL CURVE(X,Z,APT,NCV,JOPRT(L))
1958 CONTINUE
2008 CONTINUE
C
RETURN
END

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* ELT PLOT,1,748727, 50267

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000001 SUBROUTINE PLOT(IX,IV,K,NCT)
000002 DIMENSION A(51,101),SYM(9)
000003 COMMON /LAB/ TITLE(18),XLAB(11),YLAB(6)
000004 1,HORIZ(20),VERT(7,6),IT
000005 DATA SYM / 4H-----,4H-----, 4HIIII, 4HXXXX, 4H-----, 4H2222,
000006 1 4H , 4HIII, 4H----- /
000007 IF(K-99) 200,220,230
000008 200 A(51-IV,IX+1)=SYM(K)
000009 RETURN
000010 220 CONTINUE
000011 I=0
000012 WRITE(6,103) TITLE,NCT
000013 DO 225 II=1,6
000014 I=I+1
000015 WRITE(6,101) YLAB(II),(A(I,J),J=1,101)
000016 IF(II.EQ.6) GO TO 228
000017 DO 224 JJ=1,9
000018 I=I+1
000019 IF(II.NE.28) GO TO 221
000020 WRITE (6,108) VERT(5,IT),VERT(6,IT),VERT(7,IT),(A(I,J),J=1,101)
000021 GO TO 224
000022 221 IF(II.NE.24) GO TO 222
000023 WRITE (6,106) VERT(1,IT),VERT(2,IT),(A(I,J),J=1,101)
000024 GO TO 224
000025 222 IF(II.NE.26) GO TO 223
000026 WRITE (6,106) VERT(3,IT),VERT(4,IT),(A(I,J),J=1,101)
000027 GO TO 224
000028 223 WRITE(6,108) (A(I,J),J=1,101)
000029 224 CONTINUE
000030 225 CONTINUE
000031 228 CONTINUE
000032 WRITE(6,102) XLAB
000033 WRITE(6,105) HORIZ
000034 100 FORMAT(10X,101A1)
000035 101 FORMAT( 1 , 1PE16.2,1X, 101A1 )
000036 102 FORMAT ( 1 , F10.1, 10F10.1 )
000037 103 FORMAT(1H1,20X,18A4,16/)
000038 105 FORMAT(30X,20A4)
000039 106 FORMAT(3X,2A4,7X,101A1)
000040 107 FORMAT ( 1 , 1PE16.2,1X,101A1 )
000041 108 FORMAT (3X,3A4,3X,101A1)
000042 230 DO 250 I=1,50
000043 DO 240 J=1,101
000044 A(I,J)=SYM(7)
000045 A(I,1)=SYM(8)
000046 250 CONTINUE
000047 DO 260 J=1,101
000048 260 A(51,J)=SYM(9)
000049 DO 270 I=1,101,10
000050 270 A(51,I)=SYM(8)
000051 DO 290 I=1,41,10
000052 A(I,1)=SYM(9)
000053 290 CONTINUE
000054 RETURN
000055 END

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STEVE, 526338, 1, 58
END CUR, ISD VERSION 2.14

27 JUL 74 13:57:47 PAGE 33

COST DETERMINATION PROGRAM

The cost determination program listing is presented on the following sheets identified as Pages 1 through 12.

```

00120 1*
00121 2* C=.....DRIVING ROUTINE FOR RIBCO COST ANALYSIS.....
00122 3* C=.....PROGRAMED BY BILL NORTON, JANUARY 1974.....
00123 4* C=
00124 5* COMMON /ABLK/ TITLE(20),ENR,ICR,IPR,GTOT
00125 6* DIMENSION IO(4)
00126 7* DATA IO/4*PIPE,4*HOUTL,4*CHAN,4*POND/
00127 8* ICR = 5
00128 9* IPR = 6
00129 10* GTOT = 3.4
00130 11* C=
00131 12* C=.....INPUT COMMENT AND ENR INDEX.....
00132 13* C=
00133 14* 50 READ(ICR,5005,END=999) TITLE
00134 15* READ(ICR,5006) ENR
00135 16* C=
00136 17* C=.....READ CONTROL PARAMETERS AND CALL SELECTED ROUTINES.....
00137 18* C=
00138 19* 100 READ(ICR,5010,END=999) N,IDX
00139 20* 5010 FORMAT( 15,1X,A4 )
00140 21* IF( IDX .EQ. IO(1) ) CALL PIPES(N)
00141 22* IF( IDX .EQ. IO(2) ) CALL OUTLET(N)
00142 23* IF( IDX .EQ. IO(3) ) CALL CHANEL(N)
00143 24* IF( IDX .EQ. IO(4) ) CALL PONDOS(N)
00144 25* IF( IDX .NE. 4*PRIN ) GO TO 100
00145 26* WRITE(IPR,6005) GTOT
00146 27* GTOT = 0.0
00147 28* 6005 FORMAT( 1H1 // '..... GRAND TOTAL FOR ALL ABOVE FACILITIES IS' ,
00148 29* 1 -3P10.1, ' (KS) .....' )
00149 30* GO TO 50
00150 31* 999 STOP
00151 32* 5005 FORMAT( 20A4 )
00152 33* 5010 FORMAT( F10.0 )
00153 34* END

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00101 SUBROUTINE CHANEL(N)
00102 C=
00103 C= ..... ROUTINE TO COST TRAPIZODAL CHANNELS.....
00104 C=
00105 COMMON /ASLK/ TITLE(20),ENR,ICR,IPR,GTOT
00106 DIMENSION UCL(4)
00107 DATA UCL/0.12,1.25,1.65,2.25/,UCCL,UCRL/1.20,1.35/,UCEX/3.3/
00108 C=
00109 C= .....PRINT HEADINGS.....
00110 C=
00111 WRITE(IPR,6003)
00112 WRITE(6,6010) TITLE
00113 WRITE(6,6015) ENR
00114 IF( N .GT. 8 ) GO TO 200
00115 WRITE(IPR,6020)
00116

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00131 RETURN
00132 C=.....INITIALIZE FOR THIS RUN.....
00133 C=
00134 200 TVOL = 0.0
00135 TLAND = 0.0
00136 TEXC = 0.0
00137 TLANDC = 0.0
00138 TCCL = 0.0
00139 TCCL = 0.0
00140 TSURT = 0.0
00141 TCOST = 0.0
00142 ENRF = FNR/143.0
00143 C=.....ENTER INPUT AND CALCULATION LOOP.....
00144 C=
00145 LP = 15
00146 *RTE(CPR,5255)
00147 *RTE(CPR,5256)
00148 DO 220 A = 1, N
00149 IF (LP.NE.50) GO TO 220
00150 *RTE(CPR,5259)
00151 *RTE(CPR,5260)
00152 *RTE(CPR,5261)
00153 *RTE(CPR,5262)
00154 LP = N
00155 220 LP = LP + 1
00156 READ(CPR,5310) J,D1,B1,S1,D2,B2,S2,XL,ICLS,ILYN
00157 5010 FORMAT (B, 7F9.0, 2B)
00158 C=.....CALCULATE QUANTITIES.....
00159 C=
00160 A1 = 0.1 * B1 + S1 * D1
00161 A2 = 0.2 * (B2 + S2 * D2)
00162 A1 = B1 + 2.0 * S1 * D1
00163 A2 = B2 + 2.0 * S2 * D2
00164 EXVOL = (A2 - A1) * XL / 27.0
00165 ALAND = (A2 - A1) * XL
00166 P = B2 + 2.0 * S2 * D2 * (S2 * D2) * 2
00167 C=.....CALCULATE COSTS FOR THIS CHANNEL.....
00168 C=
00169 CEXVOL = EXVOL*UCEX
00170 CALAND = UCL(ICLS)*ALAND
00171 ALAND = ALAND/43500.0
00172 CCL = 0.0
00173 CCL = 0.0
00174 IF (ILYN.LE.0) GO TO 248
00175 IF (ILYN.EQ.1) CCL = P*XL*UCL
00176 IF (ILYN.EQ.2) CCL = P*XL*UCL
00177 240 CEXVOL = ENRF * CEXVOL
00178 CCL = ENRF * CCL
00179 CCL = CCL * ENRF
00180 SUBT = CEXVOL + CCL + CCL
00181 SUBT = 1.5 * SUBT
00182 COST = SUBT * CALAND
00183 C=.....ACCUMULATE COSTS.....
00184 C=
00185 TVOL = TVOL + EXVOL
00186 TCOST = TCOST + COST
00187 C=
00188 C=
00189 C=
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00101 SUBROUTINE OUTLET(N)
00102
00103 C=
00104 C=.....ROUTINE TO COST INLETS AND OUTLETS.....
00105 C=
00106 COMMON /ABLX/ TITLE(20),ENR,ICR,IPR,GTOT
00107 DIMENSION NAME(3)
00108 DATA CPT/40.0/
00109 C=.....PERFORM THE COST ANALYSIS.....
00110 C=
00111 TCOST = 0.0
00112 ENR = ENR/1450.0
00113 DO 100 K = 1, N
00114 IF (MOD(K,40) .NE. 1) GO TO 130
00115 C=
00116 PRINT HEADINGS.....
00117 C=
00118 WRITE(100,6003)
00119 WRITE(6,5010) TITLE
00120 WRITE(6,5015) ENR
00121 IF (N .LE. 0) GO TO 210
00122 WRITE(100,6020)
00123
00124 130 READ(ICR,5010) NO,DEPTH,DIA,NAME
00125 COST = CPT*DIA*.150*ENR
00126 TCOST = TCOST + COST
00127 C=
00128 PRINT RESULTS.....
00129 C=
00130 WRITE(100,6030) NO,DEPTH,DIA,COST,NAME
00131 150 CONTINUE
00132 170 CONTINUE
00133 GTOT = GTOT + TCOST
00134 WRITE(100,5035) N,TCOST
00135 RETURN
00136 210 WRITE(100,6020)
00137
00138 5010 FORMAT (15, 2F12.0, 3A4 )
00139 5035 FORMAT (14, // 10X, 'PIPE,CHANNEL,OUTLET AND POND COST ANALYSIS PR
00140 LOGICAL....., /
00141 2 10X, 'PROCEDURES DEVELOPED FOR COST ANALYSIS OF DRAINAGE PROBLEM
00142 3S X24R SEATTLE....., /
00143 4 10X, 'COST PROGRAM WRITTEN FOR THE RISCO PROJECT....., ' )
00144 6010 FORMAT ( // 10X, 28A4 )
00145 6015 FORMAT ( // 10X, 'COSTS ARE BASED UPON AN ENR CONSTRUCTION COST IND
00146 15X 0.1, ' F10.0 )
00147 6020 FORMAT ( // 10X, 'NO OUTLETS TO BE COSTED IN THIS RUN....., ' )
00148 6022 FORMAT ( // 10X, '..... COST SUMMARY FOR INLETS AND OUTLETS ....., '
00149 1 / 10X, '..... TOTAL COST INCLUDES SPX FOR CONTRACTORS PROFIT,
00150 2 ENGINEERING, LEGAL, AND CONTINGENCIES ....., ' )
00151 6025 FORMAT ( // 8X, 'NO AVE PIPE TOTAL' /
00152 1 15X, 'DEPTH DIA COST' /10X, '(FT) (IN) (KS)' )
00153 6030 FORMAT (10X, 2F12.1, -3PF12.2, 2X, 3A4 )
00154 6035 FORMAT ( // 10X, 'TOTAL FOR 14, 1 ITEMS 1, -3PF9.1 )
00155 END

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00101 SUBROUTINE PIPES(N)
00102
00103 C=
00104 C=.....ROUTINE FOR COSTING PIPES.....
00105 C=
00106 COMMON /ABLK/ TITLE(20),ENR,ICR,IPR,GTOT
00107 DIMENSION NC(100),LENGTH(100),DIA(100),DEPTH(100),P(5),
00108 1 INDEX(100,5),A(5),ADD(5),C(5)
00109 DIMENSION CA(4),CB(4),CC(4),CD(4)
00110

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00126 19* DATA C4/2.0,0.07282,0.0735,0.0796/CB/2.1,56.1,95.1,58/,
00127 20* 1 REAL C5/2.0,0.0862,0.0892,0.431/CB/2.0,2462,0.287,0.181/
00128 21* REAL LENGTH,L,INPIPE,INDEX
00129 22* C1 = 0.0
00130 23* C2 = 0.0
00131 24* C3 = 0.0
00132 25* C4 = 0.0
00133 26* C5 = 0.0
00134 27* C6 = 0.0
00135 28* C7 = 0.0
00136 29* TC2 = 0.0
00137 30* TC3 = 0.0
00138 31* TOTAL = 0.0
00139 32* EXV = 0.0
00140 33* CENV = 0.0
00141 34*
00142 35* C=.....PRINT HEADINGS.....
00143 36* C=
00144 37* 6003 FORMAT(141 // 10X, 'PIPE,CHANNEL,OUTLET AND POND COST ANALYSIS PR
00145 38* 10GRAM.....' /
00146 39* 2 10X, 'PROCEDURES DEVELOPED FOR COST ANALYSIS OF DRAINAGE PROBLEM
00147 40* 3S NEAR SEATTLE.....' /
00148 41* 4 10X, 'COST PROGRAM WRITTEN FOR THE WBCO PROJECT.....' )
00149 42* 6010 FORMAT( // 10X,20A4 )
00150 43* 6015 FORMAT( // 10X, 'COSTS ARE BASED UPON AN ENR CONSTRUCTION COST IND
00151 44* 1EX OF1, F10.0 )
00152 45* IF( N.GT.0 ) GO TO 202
00153 46* *RITECIP,6020)
00154 47* 6020 FORMAT( // 10X, 'NO PIPES INPUT FOR COST ANALYSIS' )
00155 48* GO TO 300
00156 49* 200 READ(1CR,100) (NO(I),DIAM(I),LENGTH(I),DEPTH(I),
00157 50* 1 (INDEX(I),J),J=1,5), K=1,N)
00158 51* 100 FORMAT(110, JE10.0, 5F5.0 )
00159 52* C=
00160 53* C=.....SETUP BASIC PARAMETERS FOR PIPE COSTS.....
00161 54* C=
00162 55* Y = ENR / 1450.0
00163 56* POH = 1.5
00164 57* P1 = 4.00 * Y
00165 58* P2 = 2.50 * Y
00166 59* P3 = 1.75 * Y
00167 60* P4 = 28.0 * Y
00168 61* P5 = 0.70 * Z**0.43 * Y
00169 62* P6 = 0.73 * Y
00170 63* DO 103 J = 1, 5
00171 64* C(J) = 0.0
00172 65* 103 CONTINUE
00173 66* C=
00174 67* C=.....DETERMINE COST FOR PIPE INSTALLATIONS.....
00175 68* C=
00176 69* DO 94 I = 1, N
00177 70* IF MOD(I,30).NE.1 ) GO TO 25
00178 71* *RITECIP,6030)
00179 72* *RITE(6,4010) TITLE
00180 73* *RITE(6,6010) ENR
00181 74* *RITECIP,6025)
00182 75* *RITECIP,100)
00183 76* 25 CONTINUE
00184 77* C=
00185 78* C=

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01221 69*      D = DIA(I)
01222 70*      Z = DEPTH(I)
01223 71*      L = LENGTH(I)
01224 72*      Z1 = Z - 9/12.0
01225 73*      D1 = D/12.0
01226 74*      WLOAD = 17.78*0.0.95*Z1
01227 75*      ALOAD = 2300.0*D1
01230 76*      IFC WLOAD .GT. ALOAD ) GO TO 30
01231 77*      IFC ALOAD .GT. ALOAD ) GO TO 30
01233 78*      ICL = 3
01234 79*      GO TO 50
01235 80*      30 ALOAD = 3000.0*D1
01236 81*      IFC WLOAD .GT. ALOAD ) GO TO 40
01240 82*      ICL = 4
01241 83*      GO TO 50
01242 84*      40 ALOAD = 3750.0*D1
01243 85*      IFC WLOAD .GT. ALOAD ) GO TO 45
01245 86*      ICL = 5
01246 87*      GO TO 50
01247 88*      45 ICL = 6
01250 89*      50 MARK = 7 - ICL
01250 90*
01250 91*      C=.....PIPE COST BASED ON SIZE AND CLASS.....
01250 92*      C=
01251 93*      COST = Y*L*CA(MARK)*D*CB(MARK)
01252 94*      54 TC2 = TC2 + COST
01252 95*      C=.....EXCAVATION VOLUME AND COST.....
01252 96*      C=
01252 97*      XE = ( D1 + 3.0 ) * Z * L / 27.0
01253 98*      EXV = EXV + XE
01254 99*      XC = XE * P2
01255 100*      CEV = CEV + XC
01256 101*      C=.....COST OF GRAVEL TO TOP OF PIPE.....
01256 102*      C=
01256 103*      GC = ( D1 + 3.0 ) * D1 * P1 * L / 27.0
01256 104*      TC3 = TC3 + GC
01257 105*      C=.....COST OF PIPE INSTALLED SPECIAL FORMULA.....
01257 106*      C=
01257 107*      IF( Z .GT. 12.0 ) GO TO 60
01260 108*      S1 = 0.118
01260 109*      B = CC(MARK)
01261 110*      GO TO 70
01263 111*      60 S1 = 0.45
01264 112*      B = CD(MARK)
01265 113*      70 INPIPE = B*0.15*Z*0.31*Y*L*POM
01266 114*      C7 = C7 + INPIPE
01270 115*      C=.....DETERMINE COST FOR ADDED ITEMS.....
01271 116*      C=
01271 117*      C=.....IMPORTED EARTH BACKFILL.....
01271 118*      C=
01271 119*      P(1) = P3
01271 120*      IF( Z .GT. 12.0 ) GO TO 32
01271 121*      A(1) = ( D1 + 3.0 ) * Z1 / 27.0
01272 122*      GO TO 34
01273 123*      32 A(1) = 1.0
01275 124*      P(1) = 0.1*0.0.0.75*Y
01276 125*
01277 126*
01277 127*
01277 128*
01277 129*

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00101 1* SUBROUTINE POND(N)
00101 2* C=
00101 3* C=.....THIS ROUTINE COMPUTES COSTS FOR HOLDING PONDS.....
00101 4* C=
00101 5* COMMON /ABLK/ TITLE(20),ENR,ICR,IPR,GTOT
00101 6* DIMENSION IR(4),H(4),XL(4),UCL(4)
00101 7* DATA UCL/1.12,1.05,1.65,2.25/,UCEV/2.9/
00101 8* C=
00101 9* C=.....PRINT HEADINGS.....
00101 10* C=
00101 11* WRITE(IPR,6003)
00101 12* WRITE(6,6010) TITLE
00101 13* WRITE(6,6015) ENR
00101 14* IF( N .GT. 0 ) GO TO 200
00101 15* WRITE(IPR,6020)
00101 16* RETURN
00101 17* C=
00101 18* C=.....INITIALIZE FOR THIS RUN.....

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11* 00127
20* 00130
21* ENR = ENR/1450.0
22* STOT = 0.0
23*
24* C=.....ENTER INPUT AND CALCULATION LOOP.....
25* C=
26*
27* WRITE(IPR,6055)
28* WRITE(IPR,6060)
29* DO 280 K = 1, N
30* READ(ICR,5010,END=999) J,SVOL,AREA,SPILL,ICLS
31* READ(ICR,5015) ( IR(M),H(M),XL(M), M=1,4)
32* TEV = 0.0
33* TCEV = 0.0
34* DO 215 M = 1, 4
35* IF ( IR(M) .LE. 0 ) GO TO 220
36* EV = H(M)*( 12.0+3.0*H(M)) + 9.0*H(M) + 18.0
37* EV = EV*XL(M)/27.0
38* CEV = EV*UCEV*ENR
39* TEV = TEV + EV
40* TCEV = TCEV + CEV
41* WRITE(IPR,6065) J,IR(M),H(M),XL(M),ICLS,EV,CEV
42*
43* 215 CONTINUE
44* C=
45* C=.....CALCULATE OTHER COSTS.....
46* C=
47* 220 CSPILL = 4800.0
48* IF ( SPILL .GT. 149.9 ) CSPILL = 8000.0
49* IF ( SPILL .GT. 499.9 ) CSPILL = 12000.0
50* IF ( SPILL .GT. 999.9 ) CSPILL = 16000.0
51* CLAND = AREA*ICLS/43560.0
52* CSPILL = CSPILL*ENR
53* COUT = 4800.0*ENR
54* SUBT = 1.5*(TCEV+CSPILL+COUT)
55* COST = SUBT + CLAND
56* WRITE(IPR,6070) J,SVOL,AREA,SPILL,ICLS,TEV,TCEV,COUT,CSPILL,
57* 1 SUBT,CLAND,COST
58* STOT = STOT + COST
59* 280 CONTINUE
60* STOT = STOT + STOT
61* WRITE(IPR,6080) N, STOT
62* 999 CONTINUE
63* RETURN
64*
65* 5010 FORMAT( 15, 3F10.0, 11X )
66* 5015 FORMAT( 4(15,F5.0,F10.0) )
67*
68* 6003 FORMAT( 1H1 // 10X, 'PIPE,CHANNEL,OUTLET AND POND COST ANALYSIS PR
69* 10GRAM.....' /
70* 2 10X, 'PROCEDURES DEVELOPED FOR COST ANALYSIS OF DRAINAGE PROBLEM
71* 3S NEAR SEATTLE.....' /
72* 4 10X, 'COST PROGRAM WRITTEN FOR THE RISCO PROJECT.....' )
73* 6010 FORMAT( // 10X, 20A4 )
74* 6015 FORMAT( // 10X, 'COSTS ARE BASED UPON AN ENR CONSTRUCTION COST IN
75* 15X OF 1, F12.0 )
76* 6020 FORMAT( // 10X, 'NO OPEN PONDS TO BE COSTED IN THIS RUN.....' )
77* 6025 FORMAT( // 10X, '..... COST SUMMARY FOR HOLDING PONDS .....' )
78* 1 / 10X, '..... SUBTOTAL COST INCLUDES 50X FOR CONTRACTORS PROFIT,
79* 2 ENGINEERING, LEGAL, AND CONTINGENCIES ....' )
80* 6060 FORMAT( // 14X, 'EMBANK VOLUME' 15X,

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00263	794	1 'SPILL	LAND	EMBANK	OUTLET	SPLWAY	SUBTOT	LA
00263	800	2ND TOTAL /						
00263	801	3'X, 'NO RCH						
00263	810	4 CATEGORY	VOLUME	COST	STORAGE	AREA	CAPACITY	C
00263	820	6 / 16X, (FT)	(AF)	(ACRES)	COST	COST	COST	
00263	830	7 (CY)	(K\$)	(K\$)	(K\$)	(K\$)	16X,	
00263	840							
00263	850							
00264	860	6005 FORMAT(215, F10.1,F10.0,I40,F10.1,-3P8.1)						
00265	870	6006 FORMAT(15, F35.1, 2F10.1,I10,F10.1,-3P8F8.1 /)						
00266	880	6008 FORMAT / / 10X, I TOTAL COST FOR 14, 1 HOLDING POND3' ,						
00267	890	1 -3P10.1, 1 (K\$) 1)						
00267	900	END						